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Radiation mechanisms of astrophysical objects: classics today

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Contents

Some structural features of vortices in gravitating gaseous disk

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The linear and non-linear vertical perturbations of rotating gravitating gaseous disc in frame of geostrophic and post-geostrophic approximations are investigated. The structure of mono-pole and solitary dipole vortices (modon)-solutions of obtained equations is studied. Two types of mass distribution in a solitary dipole vortex are received. The first type is characterized by antisymmetrically located counter rotating one round condensation and one rarefaction. The second type is characterized by anti-symmetrically located two condensations and two rarefaction, and a second pair of condensation-rarefaction has a sickle form. Contours of constant density of short-scale dipole vortex match the current lines of vortex; in a gravitating modon the contours of constant density does not coincide with the current lines. The possible applications of monopoly and dipole vortex in astrophysical objects have been discussed.

Atomic data for inelastic processes in low-energy rubidium-hydrogen collisions

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Atomic collisions of atoms and positive ions of different chemical elements with hydrogen atoms and negative ions are a main source of uncertainty for non-LTE studies due to high concentrations of hydrogen atoms. Accurte quantum studies are time-consuming and laborous, that's why reliable model aproach is very important. In order to evaluate physically reliable rate constants, the model approach within the framework of the Born-Oppenheimer formalism has been very recently proposed [1,2]. The approach is based on the asymptotic method for electronic structure calculations and multichannel Landau-Zener model for a nonadiabatic nuclear dynamical treatment.

In the present study low-energy collisions of rubidium with hydrogen are considered. Electronic structure calculations involved 5 low-lying levels and one ionic. Nonadiabatic transition probabilities between molecular states are calculated by using the multichannel formula based on the Landau-Zener model. Rate coefficients for excitation, de-excitation, ion-pair formation and mutual neutralization processes in rubidium and hydroger collisions are calculated and processes important for astrophysics are defined.

[1] A.K. Belyaev, Phys. Rev. A, **88**, 052704 (2013).

[2] A.K. Belyaev, S.A. Yakovleva , P.S. Barklem , Astron. Astrophys., **572**, A103 (2014).

Photoelectric and collisional charging of dust in protoplanetary disks

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Grain charging in protoplanetary disks and its impact on the dust growth lacks currently a detailed scientific scrutiny. In this work we consider two of the primary mechanisms of the dust charging — photoelectric effect and collision with electrons and ions. To study the impact of the grain charge on the dust coagulation we solve the Smoluchowski equation locally for typical disk parameters. The collisional charging, which dominates in the disk midplane, leads to electrostatic repulsion between negatively charged grains. This poses a known problem of the electrostatic barrier against dust growth, that significantly hampers dust growth. In the disk atmosphere, where photoelectric charging operates and grains are positively charged, dust retains its initial size distribution both due to low number density and electrostatic repulsion. The most interesting case is at intermediate heights near the zero charge surface, where collisional and photoelectric charging mechanisms are comparable. The presence of both negatively and positively charged grains at the intermediate heights leads to a significant increase in dust coagulation rates, which competes even with coagulation rates in the disk midplane. Such a vertically non-uniform dust evolution affects total available grain surface and UV field distribution, which are of great importance for disk chemistry and appearance.

Studies of cosmic water and hydroxyl masers within the "RadioAstron" Space-VLBI project

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RadioAstron observations of the cosmic masers led to a number of successful detections in both water and hydroxyl maser transitions. The presence of numerous ultra-compact details shows that implementation of the space-VLBI technique for maser studies is technically possible and is not always prevented by the interstellar scattering, maser beaming and other effects related to formation, transfer and detection of the cosmic maser emission.

The first time space-VLBI detections of cosmic water maser emission have been obtained for the Megamaser galaxy NGC 4258 and various star forming regions of the Galaxy. The sharpest "direct" linear resolution of better than 4 million kilometers has been achieved in observations of the water maser in Orion. Water masers in W49N were detected on baselines exceeding 9.5 Earth Diameters, which corresponds to the ultra-high angular resolution of about 23 microarcsec.

The nature of long-term spectral variability of IN Com

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We are presented long-term spectral observations ($R = 20000$) of IN Com in the region of H_α, H_β and He I 5876 lines. The distinguishing character of stellar spectrum is the presence in the H_α line the extended two-component emission with limits reached $\pm$400 km/s. Emission parameters show the rotation modulation with the stellar rotation period and a significant variability on the long-term scale. Similar emission is observed also in H_β and He I 5876 lines. Our results allow to conclude that observational emission profiles are formed in optically thin hot gas. It is a result of presence around IN Com circumstellar gas disk. Its size is not exceed some stellar radii. The material for the disk is supported by IN Com stellar wind. The found variability of H_α emission parameters shows evident connection with photopolarimetric activity of the star. This fact allows us to connect the long-term spectral variability with cycles of stellar activity of IN Com.

The non-local thermodynamic equilibrium (NLTE) line formation of C I – C II in the A- and late B-type stars

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Classical LTE analysis finds a discrepancy in abundances determined from different lines of C I, as well as a violation of the ionization equilibrium between C I and C II in the atmospheres of A and late B type stars. We present a new comprehensive model atom for C I – C II designed to investigate line formation for C I and C II based on the non-local thermodynamic equilibrium (NLTE). As a first application of the C I – C II model atom, carbon abundances are determined on the basis of classical plane-parallel model atmospheres for Vega (A0 V), HD 73666, 21 Peg, and π Cet that show no obvious sign of chemical peculiarity. π Cet shows a emission lines in the near-infrared spectral region (8335 Å and 9405 Å). We show that the C I emission lines are explained by NLTE effects but not the circumstellar disk. The NLTE analysis helps to achieve the ionization equilibrium between C I and C II in the atmospheres of A and late B type stars for the presented stars.

Dynamics of wind and variations of circumstellar extinction in the classical T Tauri star RY Tau

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RY Tau is a pre-main sequence star with accretion disc. With the spectral type G2 and stellar mass of 2 $\mathfrak{M}_\odot$ it drops in between the Classical T Tauri stars and the Herbig Ae stars. Light variability of RY Tau is mostly due to variable circumstellar extinction, because the line of sight lies near to the disc plane. From the highly variable H_α and NaI D line profiles we identified magnetospheric accretion flows, disc wind, and events of fast outflows (P Cyg profile), which are probably a coronal mass ejection following the magnetosphere inflation. For the first time it is found that the circumstellar extinction is tightly related to the wind: extinction gets lower at higher velocity of the wind. We suggest that the coronal mass ejection events modify the dusty disk wind within ≈ 0.3 AU from the star, and temporarily clear up the line of sight from the dust particles.

Molecular hydrogen absorption systems at high redshifts

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Molecular hydrogen absorption systems are corresponded to the cold phase of interstellar medium of the galaxies in the early Universe. They are detected in the quasar spectra and found to be associated with the Damped L_α systems. We present a small review of studies of H_2 absorption systems and focus on recent progress that was done by our group, namely:

(i) the search of H_2 absorption systems in SDSS quasar spectra;

(ii) the measurement of neutral chlorine abundance in all known H_2 absorption systems at high redshifts ($z = 2 \div 4$);

(iii) the study of ultra high H_2 column density absorption system at $z = 2.7865$ in spectrum of J0843+0221.

Spectral distortions of the CMB dipole

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We consider the distortions of the CMB dipole anisotropy related to the primordial recombination radiation (PRR) and primordial y- and μ-distortions. The signals arise due to our motion relative to the CMB restframe and appear as a frequency-dependent distortion of the CMB temperature dipole. To leading order, the expected relative distortion of CMB dipole does not depend on the particular observation directions and reaches the level of 10^{-6} for the PRR- and μ-distortions and 10^{-5} for the y-distortion in the frequency range $1 \div 700$ GHz. The temperature differences arising from the dipole anisotropy of the relic CMB distortions depend on observation directions. For mutually opposite directions, collinear to the CMB dipole axis, the temperature differences because of the PRR- and μ-dipole anisotropy attain values $\Delta T \simeq 10$ nK in the considered range. The temperature difference arising from the y-dipole anisotropy may reach values up to 1 μK. The key features of the considered effect are:

(i) an observation of the effect does not require absolute calibration;

(ii) patches of sky with minimal foreground contamination can be chosen.

Future measurements of the CMB dipole distortion thus provide an alternative method for direct detection of the PRR-, y- and μ-distortions. The y-distortion dipole may be detectable with PIXIE at a few standard deviations.

The influence of small scale magnetic field on the polar cap X-ray luminosity of old radio pulsars

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The influence of small-scale magnetic field on the polar cap heating by reverse positrons is considered. We use the polar cap model with steady space charge limited electron flow. To calculate the electron-positron pairs production rate we take into account only the curvature radiation of primary electrons and its absorption in magnetic field. The reverse positron current is calculated in the framework of two models: rapid (J. Arons, E.T. Scharlemann (1979)) and gradually screening (A.K. Harding, A.G. Muslimov (2001), Yu.E. Lyubarskii (1992)). It is shown that some pulsars are better described by the rapid screening model and some other pulsars have better agreement with calculation by the gradually screening model.

The work has been partly supported by the RFBR (project 13-02-00112) and by the State Program "Leading Scientific Schools of the Russian Federation" (grant NSh-294.2014.2).

On the localization of emission lines region in Mira stars

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New evidence is obtained that hydrogen emission lines as well as metallic ones originate below molecular line absorbing layers in spectra of Mira stars.

The time scale t_c is calculated as function of T_0 for the final stage of gas cooling behind a shock wave propagating through the star atmosphere, when gas temperature tends to its preshock value T_0. We have computed t_c for $T_0 = (2800 \div 3000)$ K, which is typical values for the layers absorbing in the molecular lines, and have compared it with the pulsation period P of S Car, T Col, RR Sco, R Aql, R Car, o Cet, RR Sgr, S Sco, W Vel, R Leo. It occurs that the gas has no sufficient time to be cooled to its preshock state. So, T_0 should be greater than temperature of molecular layer.

This result is agrees with the spectra of Mira-like stars known in the literature. The emission lines show a complex structure, having an asymmetric, or a multicomponent profile, what is due to molecular line absorption.

This work was partly supported by the Russian Foundation for Basic Research (projects 13-02-00136 and 15-03-03302).

Signs of a dead transient disk in AE Aquarii

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AE Aquarii is a low-mass binary which contains a strongly magnetized white dwarf rotating with the period of 33 seconds. Observations give no evidence for an accretion of mass onto the surface of the white dwarf and its spin-down power exceeds the bolometric luminosity of the system. We show that the peculiar appearance of the system can be explained provided the white dwarf operates as a spin-powered pulsar. The surface magnetic field of the white dwarf within this scenario is about 50 MG. Numerical simulations of the mass-transfer process suggest that the magnetosphere of the white dwarf under these conditions can be surrounded by a transient dead disk (or ring). We find the disk to be very unstable. As it is disrupted the material is flowing out from the system spreading around it. We show that the typical time of formation and disintegration of the transient disk is close to the time of the peculiar flaring activity observed in the system.

Electronic thermal conductivity in the crust of magnetized neutron stars: the solution of the kinetic equation by the Chapman-Enskog method

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The solution of the system of Boltzmann equation for plasma in magnetic field, with arbitrary degenerate electrons and non-degenerate nuclei, is obtained by Chapman-Enskog method. Three functions, generalising Sonin polynomials are used for obtaining an approximate solution. Fully ionized plasma is considered. The tensor of the heat conductivity coefficients in non-quantising magnetic field is calculated. For nondegenerate and strongly degenerate plasma the asymptotic analytic formulae are obtained, which are compared with different results of previous authors. Due to kinetic approach, our results are more exact than usually used coefficients, obtained by a simplified approach for the thermal conductivity in a plasma of a neutron star crust. For strongly degenerate plasma Lorentz approximation, with neglecting of electron-electron encounters, is asymptotically exact, and our 3-functional approximate solution gives results which deviate from an exact solution less than 3% for all values of the magnetic field. The deviation decreases with increasing of the field. The account of the electron-electron collisions for mildly degenerate plasma permits to obtain more exact results, so that for a non-degenerate plasma the maximal difference with the simplified approach, which is similar to the Lorentz approximation, is $\sim 300\%$ for the ratio of the thermal conductivity coefficients along and perpendicular to the magnetic field.

Variation of O I 6300 Å line emission in Herbig Be binary star HD 200775

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Variations of O I 6300 Å line in the spectrum of Herbig Be binary star HD 200775 are reported for the first time. The orbital period of the binary system is about 3.7 years. The system is likely to have a common disk observed in IR-emission and an accretion disk around the primary component which is probably formed due to accretion of the common disk material. Variations in equivalent width and profile of H_α line with approximately orbital period are registered in the star. It was shown that H_α line is formed in material associated with the primary component.

We tried to find a correlation of O I 6300 Å line parameters with the orbital phase and H_α activity of the star. We considered the line profiles in newly-obtained and archival spectral data over about 20 years time interval. The majority of the data were obtained at 1.2-m telescope of the Kourovka Astronomical Observatory of the Ural Federal University. We have found that the line profiles obtained at the same orbital phases are similar for different epochs and instruments. So, the orbital motions in the system are responsible for the periodic variations in the region where the O I 6300 Å line emission is formed.

Nonstationary hydrogen and helium discrete level occupation behind shock front

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Hydrogen and Helium discrete level occupation is not stationary behind a shock front in the atmospheres of G –M stars (shock velocity $20 \div 50$ km/s). This is due to the relatively high excitation energy: all the excited states of the both chemical elements are located very close to the continuun, and far from the base level (in the energy scale). As a consequence, one can not neglect electron impact ionization as compared with discrete transition rates at the least for the levels with the main quantum number $n = 2 \div 5$. This is why we should take into account the exchange between the discrete levels and the continuum, and the discrete level occupation is not stationary, as the continuum one.

Chemical elements, such as Magnesium, Iron, and other metals, have discrete level structure different from H and He. Their excited levels lay close to the base level and rather far from the continuum. The ionization rate is small compared to the deexcitation rate, an one can solve separately two different problems: nonstationary ionization and quasistationary discrete level occupation.

High energy radiation of supernova remnants and starburst regions

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Powerful stellar winds and supernova explosions with intense energy release in the form of strong collisionless shock waves are expected to convert a sizeable part of the kinetic energy release into fluctuating magnetic fields and relativistic particles. The starforming regions are known as a favorable site of energetic particle acceleration and could be efficient sources of nonthermal emission. We discuss models of energetic particle acceleration, interactions and nonthermal emission by supernova remnants in active starforming regions at different stages of their evolution. The high efficiency of particle acceleration in the sources implies the importance of nonlinear feedback effects in a symbiotic relationship where the magnetic turbulence required to accelerate the energetic particles is created by the accelerated particles themselves. Non-thermal emission produced by relativistic particles (both those confined in and those that escape from the cosmic accelerators) can be used to constrain the basic physical models of the sources. High resolution X-ray synchrotron imaging, combined with GeV–TeV gamma ray spectra, is a powerful tool to probe the maximum energies of accelerated particles. Recently the IceCube Neutrino Observatory discovered PeV regime neutrinos from astrophysical sources providing a new way to study the sources of high energy radiation. Future MeV regime spectroscopy will provide unique information on the composition of accelerated particles.

3-D NLTE radiative transfer models using the Sobolev method

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Among the important contributions of V.V. Sobolev to astrophysics is the Large Velocity Gradient method, also known as the Sobolev method, for solving the problem of line radiation transfer in moving media. This is a very important problem, occurring in many astrophysical systems such as stellar winds and gaseous disks. The Sobolev method is similar to that of a diffusion problem, and employs penetration and escape probabilities to estimate the mean intensity and the source function as a function of position in the medium.

We present the Monte Carlo radiative transfer code HDUST that uses the Sobolev method to solve the coupled problems of radiative transfer, thermal equilibrium and statistical equilibrium. The Monte Carlo method works basically by sampling the mean intensity as a function of position in the envelope. This is done by emitting a very large number of photon packets from the star (and whatever other source of radiation) and following the random path of each packet as it interacts with the medium. The Monte Carlo method is a common choice for solving continuum problems, in which the opacity is a slowly varying function of the wavelength. Examples include dust opacity and electron scattering. HDUST represents one of the few existing Monte Carlo codes that tackle the problem of line radiation transfer, in which opacities are quite strong functions of wavelength and position. In this contribution we describe how the Sobolev approximation was implemented in HDUST, and the various algorithms we developed to make the code efficient for arbitrary (3-D) geometries and velocity fields. Finally, several astrophysical examples in which HDUST were used as a tool will be described.

Radiative processes in accretion and outflows in black holes

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I discuss how radiative processes along with viscosity desegregate an initially low angular momentum transonic flow into a Chakrabarti-Titarchuk type two component advective flow (TCAF), in which the flow in the equatorial plane becomes a standard Shakura-Sunyaev type disk and the flow surrounding it advects rapidly with inefficient cooling till it reaches centrifugal barrier where the density rises to increase the cooling efficiency due to inverse Comptonization. I show that the outflow is produced primarily from the centrifugal barrier and it is quenched in the soft states due to efficient cooling. Resonance oscillation of this barrier will be shown to be responsible to cause quasi-periodic oscillations seen in X-rays and γ-rays. Finally I show how the accretion rates in the Keplerian and sub-Keplerian components vary in outburst sources, as obtained by XSPEC fitted satellite data using TCAF. We discuss possible ways magnetic fields may play a role in the spectral and timing properties and formation of outflows.

Cosmic gamma-ray bursts: a challenge for radiation processes in astrophysics

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The cosmic γ-ray bursts are certainly an enigma in astrophysics. The standard "fireball" scenario developed during many years has provided a possible explanation of this phenomena. The aim of this presentation is to explore a new possible interpretation by developing a coherent scenario inside the global picture of stellar evolution. At the basis of this scenario is the fact that maybe we have not fully understood how the core of the pair instability supernovae explodes. We have proposed a new paradigm assuming the fragmentation of the core instead of symmetric explosion. The consequences of this simple assumption, we have derived a new coherent possible scenario for GRBs. We have tested our scenario with observational data like GRB spectrum, light curves, Amati relation and GRB–SN connection, and for each we have proposed a possible physical interpretation. We have also suggested a possible test of this scenario by measurements at high redshifts.

Black holes in binary stellar systems and galactic nuclei

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No abstract.

Fine structure of solar radio emission

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The wide variety of the fine structure of solar radio emission is shown. Primary attention is given to the examination of most mysterious structure — stripes on the dynamic spectrum like of zebra. Despite the fact that for the first time zebra-structure is discovered in the meter wave band more than 50 years ago, it remains little studied. However, first of all this is connected with the wide variety of stripes and the discovery in recent years of a similar variety in the microwave range. More than ten mechanisms of radio emission were proposed, but no one of them can be considered basic or final, since they even do not pretend to the explanation of all components. Though a row from them is called models, any of them isn't brought to calculation of coefficients of radiation and absorption. In the theory of zebra-structure the mechanism of double plasma resonance (DPR) was widely adopted: when upper hybrid frequency ω_{UH} becomes equal to the integer of electronic cyclotron harmonics $s\omega_{\mathrm{Be}}$: $\omega_{\mathrm{UH}} = (\omega_{\mathrm{Pe}}^2 + \omega_{\mathrm{Be}}^2)^{1/2} = s\omega_{\mathrm{Be}}$. However, laboratory plasma experiments do not confirm the efficiency of mechanism on DPR. The author's contribution in obtaining new priority observation data for four cycles of solar activity and in creation of original uniform model for a wide variety of stripes like zebra on the basis of the mechanism of interaction of plasma Langmuir waves with low-frequency waves like whistlers is shown. The relevance of the progress of similar researches in solar radio emission grows in recent years in connection with the detection the zebra structure in the microwave radio emission of pulsar in the Crab Nebula.

Gamma-rays from type Ia supernova SN 2014J

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SN 2014J is the closest type Ia supernova in the era of space observatories and the first one from which γ-ray lines have been detected with high significance. The flux of ^{56}Co lines at 847 and 1238 keV, observed with INTEGRAL, shows that about 0.6 $\mathfrak{M}_\odot$ of radioactive ^{56}Ni has been synthesized during explosion. The line broadening suggests the characteristic expansion velocity of $\sim 10^4$ km/s. Annihilation of positrons produced during decay of ^{56}Co makes significant contribution to the continuum below 511 keV. The total mass of the ejecta is consistent with 1.4 $\mathfrak{M}_\odot$ progenitor, although the constraints are not very tight. Overall the γ-ray data are broadly consistent with the expectations for canonical 1D models, such as delayed detonation or deflagration models for a near-Chandrasekhar mass White Dwarf. Pure detonation models or strongly sub-Chandrasekhar models are excluded by the γ-ray data.

Giant radio telescopes as the detectors of UHE cosmic rays and the new possibilities with the SKA

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In the beginning of 1960s Gurgen Askaryan [1-2] had showed that interaction of SHE particles with the atoms of relatively dense dielectrics will produce the nanosecond radio pulses of Cherenkov emission. Around 25 years later the lunar Askaryan technique was proposed [3] where the Moon is used as a target and the large ground-based radio telescopes as the detectors of the pulses. It was obvious that the lunar Askaryan technique is especially interesting for detection of UHE neutrinos due to giant target volume (aperture) used in the method. However, the attempts to detect of the Cherenkov radio pulses from the Moon using the large ground-based radio telescopes taken by several groups around the world didn't give any positive result up to now and put only some upper limits on the isotropic UHE neutrino flux. Corresponding restrictions have excluded only several extremely exotic views on the nature of such neutrinos. Construction of the giant Square Kilometer Array, the radio telescope of extremely high sensitivity and very flexible multi-beam forming system, will open a new wide possibility to register the neutrinos and other cosmic rays with the energies over $10^{21} \div 10^{22}$ eV.

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Monitoring of variable radio sources at 111 MHz with the multi-beam radio telescope BSA LPI

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The results of variable radio sources observations carried out with 96-beam radio telescope BSA LPI are presented. In the frame of the monitoring program the radio emission fluctuations greater of 0.2 Jy were registered day by day for the all radio sources with declinations between $-8°$ and $+42°$. Three types of variable sources were studied: the pulsars with the typical width of their pulses about $0^s.1$, radio sources scintillating on interplanetary plasma inhomogenities (IPS with typical temporal scale is 1^s) and the sources scintillating on the ionospheric irregularities (with temporal scale of 10^s). The total number of radio sources observed for 24 hours was around 5000. Examples of 2D IPS maps show that the most parameters of the solar wind are not regular and highly variable. On the other hand, the global spatial structure of the solar wind averaged over the month is close to spherical symmetric one near the 24th solar activity maximum. The examples of the large scale disturbances propagating throw the solar wind after the solar flares are seen on the IPS maps. Several new pulsars were detected using the folding data processing algorithm.

Polarization of resonance lines in case of polarized primary sources of radiation

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Transfer of polarized radiation in a spectral line for a nonmagnetic semi-infinite plane-parallel atmosphere is considered. It is assumed that there is complete frequency redistribution; absorption in the continuum is taken into account. Primary sources of the radiation distributed in the atmosphere are partially polarized. Dependence of the primary sources on the optical depth is described by a product of polynomial and exponential functions.

The possibility of application of the general analytic theory of **I**-matrices for solving this problem is investigated (**I**-matrix is a generalization of the scalar Chandrasekhar's H-function). It is shown that the solution of the problem with any of the primary sources of this kind is expressible by the solution of the so-called standard problem.

Simulation of structures in protoplanetary disks

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The protoplanetary disk around binary stars and stars with low-mass companion are considered. Hydrodynamical calculations indicate that the gravitational interaction between the massive bodies and the surrounding disk results in global perturbations of the disk density profile. The observability of characteristic large-scale disk structures which are caused by the motion of a secondary component or a low-mass companion are investigated. The structure of protoplanetary disks are calculated using smoothed-particle hydrodynamic simulations. Subsequently, radiative transfer simulations were performed to obtain scattered light and thermal reemission maps. The influence of the mass ratio of the star and the companion, the inclination of the companion orbit relative to the disk midplane, and the eccentricity of the orbit on observational quantities are studied. Our simulations show that the presence of global density structures of the disk leads to an anisotropic illumination and heating of the disk by the star and, as a consequence, to the appearance of a large-scale inhomogeneity in the disk image. An asymmetry of the disk image is clearly seen even when it is viewed pole-on. Depending on the model parameters the bright horseshoe-shaped asymmetry, spiral arms and butterfly-shaped structures can be observed. A study of such asymmetric disks opens up new opportunities for the search of massive bodies in the neighborhoods of young stars.

Numerical simulation of electromagnetic scattering by morphologically complex objects

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The availability of modern numerical techniques and the increasing power of computers (in particular, the advent of computer clusters) have led to the emergence of new possibilities in studying the properties of electromagnetic radiation scattered by morphologically complex objects. As such objects we consider the disordered scattering media composed of particles of different shape and chemical composition. Our study is based on the results of numerical simulation performed by applying highly exact numerical methods of radiative transfer theory and direct solutions of the Maxwell equations. By means of the T-matrix and multiple-scattering calculations with full account of polarization, we demonstrate the strong effect of particle shape on the accuracy of the remote-sensing retrievals. We show the example of applying the T-matrix method, numerically exact solution of the vector radiative transfer equation, and the theory of coherent backscattering for analysis of the radar polarimetric observations of the Saturn's rings. On the basis of direct solutions of the Maxwell equations we demonstrate that all backscattering effects predicted by the low-density theories of radiative transfer and coherent backscattering can also take place in media with volume packing density encountered in natural and man-made conditions.

Nonhomogeneous atmospheres — on transforming conservative multiple scattering to nonconservative multiple pseudo-scattering

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On using the F- and K-integrals, the zeroth azimuthal I-Q-Fourier component of the radiative transfer equation for conservative multiple scattering of polarized light in a vertically nonhomogeneous plane atmosphere will be transformed into an equivalent transfer equation with a modified phase matrix corresponding to nonconservative pseudo-scattering. Generally, the modification includes two function vectors free for conveniet choice. If the modified phase matrix should preserve the original symmetry properties, the freedom of choice reduces to two scalar functions. For diffuse reflection and transmission by nonhomogeneous finite or semi-infinite plane atmospheres with conservative scattering, and also for Milne's problem, it will be shown, how to retrieve the solutions of the original conservative radiative transfer problems by means of particular solutions of the modified nonconservative transfer equation.

Non-stationary processes in atmospheres of early-type stars: influence on forbidden to intercombination ratio (f/i)

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We report the results of non-stationary level population modeling of highly ionized atoms in atmospheres of early type stars. We studied influence of these processes on forbidden to intercombination line ratio $R = f/i$ of He-like ions (C V, N VI, O VII etc.) in X-ray spectra.

It is shown that instant ratio $R_{\rm m}$ varies up to 4 orders of magnitude on short time scales (milliseconds) in comparison with with the same value for stationary plasma, if non-stationary level population is taken into account. In the same time value $R_{\rm a}$ averaged on long time scales (hours and minutes) varies by 20% which leads to overestimation of the electron density value up to 1–2 orders of magnitude.

Numerical experiments on the physical parameters of the star formation law

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Using AMR numerical simulations (ENZO), we study the functional dependence of the star-formation law in galaxies, based on the formalism developed by Escala (2015). We find that all numerical simulations follows a single law the form $\dot{\Sigma}_\star \propto \sqrt{G/L}\,\Sigma_{\rm gas}^{3/2}$, as suggested by Escala (2015). Instead, when the Kennicutt-Schmidt formulation is plotted, two sequences are found for mergers and disk-galaxies, as it was suggested by Daddi et al. (2010). In addition, we study the star formation efficiency in our simulations, finding that has an exponential dependence on the orbital time.

Ultraluminous X-ray sources as super-Eddington accretion disks

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The origin of Ultraluminous X-ray sources (ULXs) in external galaxies whose X-ray luminosities exceed those of the brightest black holes in our Galaxy by hundreds and thousands of times is mysterious. The most popular models for the ULXs involve either intermediate mass black holes (IMBHs) with standard accretion disks or stellar-mass black holes (~ 10 solar masses) accreting at super-Eddington rates. Here we review the ULX properties, their X-ray spectra indicate a presence of hot winds in their accretion disks supposing the supercritical accretion. However, the strongest evidences come from optical spectroscopy. The spectra of the ULX counterparts are very similar to that of SS 433, the only known supercritical accretor in our Galaxy.

Role of accreting compact sources in ionizing ISM in elliptical galaxies

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Elliptical galaxies are commonly observed to host extended regions of neutral and ionized gas which reveals itself via copious line emission. Outside the innermost nuclear regions, the favoured candidate ionizing source remains some component of the stellar population, with the post-Asymptotic-Giant-Branch (pAGB) stars being an important contender. Other stellar sources, such as low-mass X-ray binaries, have been claimed to be unimportant in this regard. These calculations, however, did not take into account the possible age dependence of LMXB populations. Recently, it has been shown that accreting nuclear burning white dwarfs may play a significant role, adding a hot component to the ionising UV radiation field in these galaxies. Their emission, peaking in the extreme UV and soft X-ray bands is capable to fully ionize helium, making He II recombination lines a sensitive diagnostics, in addition to commonly used recombination lines of hydrogen and forbidden lines of metals. In this talk, we will overview the role of different types of accreting compact sources to the ionization and excitation of neutral/warm ISM in elliptical galaxies. We will compare predictions of state of the art population synthesis calculations combined with extensive grids of photoionisation calculations, with stacked age-resolved spectra of passively evolving galaxies from the Sloan Digital Sky Survey.

Polarimetric method of V.V. Sobolev for measuring black hole masses in active galactic nuclei

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The structure of the broad emission line region (BLR) in Active Galactic Nuclei (AGN) are unclear. The model of a flattened configuration for BLR is very popular. The virial theorem with taking into account the disc shape of BLR allows to get the direct connection between the mass of a super massive black hole (SMBH) and the inclination of the accretion flow. The inclination angle itself is derived at the base of spectropolarimetric data of broad emission lines on the base of the theory of generation of polarized radiation developed by V. Sobolev and S. Chandrasekhar.

In a result, new estimates of SMBH masses in AGN with measured polarization of broad lines emission are presented. It is very important that the polarimetric data allow us also to determine the value of the virial parameter that is very essential for determination of SMBH masses.

Properties of the solar polar coronal holes radiation according to radio observations

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A brief review of observations of radio emission comimg from the regions over the Solar poles in a wide wavelengts range from meters to millimeters with various radio telescopes is given. The results of observations of coronal hole (CH) over the North Pole of the Sun with the RATAN–600 in a broad centimeter wavelength range ($1.03 \div 30.7$ cm) are analized. The comparison of the obtained physical characteristics (electron densities ne and brightness temperatures) for CH over the North Pole Sun with those previously obtained with RATAN–600 for CH whis was located in the lower latitude is presented.

A 2D model of non-stationary accretion onto a magnetized neutron star

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Based on the 1D model of non-stationary accretion onto a magnetized neutron star developed by Bykov and Krassilchtchikov in 2004, we have developed a new 2D model of an accretion column which takes advatage of a Godunov-type numerical scheme specifically tailored for the employed dipolar coordinate system and keeps account for the microphysics, such as interactions of the downstreaming ions and electrons with the non-resonant and resonant radiation field. The new model yields flow profiles compatible with that of the original one, in particular, it shows how a collisionless shock comes out and evolves in the column.

The Sobolev approximation in the development and astrophysical applications

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The Sobolev approximation is one of the most effective method of the modeling of emitting regions in astrophysical objects of various types. It plays also an important role in the radiative hydrodynamics. In my review talk, after the short introduction to the Sobolev method, I discuss the main steps in its development and astrophysical applications.

Description of frequency redistribution functions via bilinear expansions

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Bilinear expansions of Redistribution functions (RFs) are useful tools both for the approximate numerical calculations of RF itself and for solving the radiation transfer problems. Hereby an attempt to build a bilinear expansion for the angle averaged RF derived by V.V. Sobolev in 1955 independently by other authors is made. This redistribution law describes the photon frequency change probability during the elementary act of scattering in a resonance line when the combined effect of upper energetic level natural blurriness and the Doppler effect of atoms' chaotic motion are taken into account. In this case the bilinear expansion is represented as follows:

$$r_{\mathrm{II\,A}}(x',x)=\sum_{k=0}^{\infty}\frac{\omega_{2k}(x',\sigma)\,\omega_{2k}(x,\sigma)}{\lambda_k(\sigma)},$$

where the eigenfunctions $\omega_{2k}(x,\sigma)$ represent superpositions built of some orthonormal functions $\alpha_{2k}(x)$

$$\omega_{2k}(x,\sigma)=\sum_{k=0}^{\infty}\gamma_{km}(\sigma)\,\alpha_{2m}(x),$$

and the functions $\alpha_{2k}(x)$ have the following form:

$$\alpha_{2k}(x)=\frac{H_{2k}(x)\,e^{-x^2}}{2^k\,\pi^{1/4}\,(2k)!}.$$

$H_{2k}(x)$ are the Hermit polynomials of $2k$-th order.

The problem is reduced to the determination of the eigenvalues and eigenfunctions from

$$\sum_{m=0}^{\infty}\gamma_{km}\,[a_{mn}-\lambda_k(\sigma)\,b_{mn}(\sigma)]=0,$$

where

$$a_{mn}=\int_{-\infty}^{\infty}\alpha_{2m}(x)\,\alpha_{2n}(x)\,dx$$

and

$$b_{mn}(\sigma)=\int_{-\infty}^{\infty}\alpha_{2m}(x)\,dx\int_{-\infty}^{\infty}r_{\mathrm{II\,A}}(x',x)\,\alpha_{2n}(x')\,dx'.$$

This problem is solved numerically and the required eigenvalues and eigenfunctions have been obtained. It allows one to build the required RF. Moreover, this approach allows one to build RFs for other physical assumptions as well.

Magnetic fields in massive stars: new insights

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We will review recent results on the magnetic field characteristics of early B- and O-type stars obtained by various surveys. The results of the studies of the presence of magnetic fields in both cluster and field stars suggest further directions of investigations to be followed in view of answering the question of the field origin.

Generation of hot plasma and X-Rays in comets

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Generation of X-rays in comets due to production of hot short-living plasma clots at high-velocity collisions between cometary and interplanetary dust particles (with relative velocities equal or more than 70 km/s) is considered. It is shown that observations of dusty comets with retrograde orbital motion in the inner heliosphere by X-ray telescopes like ROSAT and XMM are of interest. Such observations may give information about cometary dust and zodiacal dust cloud around the Sun as well.

Search for high-energy photons from comets during solar flares

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Emission of impulse of high-energy photons, of the order of 0.1-1 MeV, from comets is possible during strong solar flares due to high-voltage electric discharge of a double layer that may be formed within the subsurface layer of some cometary nuclei (having sufficiently high specific electric resistance, like to some organic/polymer semiconductors at low temperatures) by intense irradiation of the nucleus with solar cosmic rays/high-energy protons and positive multicharge ions together with solar wind plasma. Such cosmic GRB-phenomenon will also be accompanied by comet optical outburst: Ibadov S., ASR, 2012, 49, 467-470.

How accreting matter enters the magnetic field of neutron stars?

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The mode by which accreting matter can enter the magnetic field of a neutron star is discussed. We show that the interchange (Rayleigh-Taylor and Kelvin-Helmholtz) instabilities of the magnetospheric boundary in the conditions of interest are suppressed. The rate of plasma diffusion into the stellar field depends on the geometry of the accretion flow and physical conditions in the material at the magnetospheric boundary. It occurs at a required rate if the neutron star accretes material from a non-keplerian magnetically levitating disk.

Mid-infrared extinction constraint on cosmic dust models

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For various interstellar (IS) environments, the extinction law in mid-infrared has been estimated from Spitzer data, and in a few cases in quite another way. The extinction was found weakly depended on environments, nearly independent of the wavelength and surprisingly high so that the available cosmic dust models being unable to explain it.

Under the assumption that the mid-IR extinction is produced by submicron spherical dirty silicate grains mainly responsible for IS extinction and polarization in near- and mid-IR regions we analyze the problem. Using a simple analytical approximation we demonstrate that there are different ways to solve the problem: from normal size very porous grains to larger size particles of smaller porosity. We also make some conclusions about the imaginary part of the mean refractive index of cosmic silicate grains. Using a detailed computational model involving the optical constants of silicates based on Jena laboratory data, we present possible solutions to the problem.

Optical spectrum variability of IL Cep A

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The results of long time investigations on the homogenous spectral material of the Herbig Ae/Be type star IL Cep A have presented. The emission line H_α has variable single and double peaked profiles which scarcely divided by central absorption. Emission line H_β has clear divided into two emission peak by central absorption. During for 9 years a smooth variability of obtained parameters of some spectral lines has been discovered. The line He I λ5876 Å shows the complex absorption profile where possible superimposed emission components. Sodium doublet Na I D1, D2 shows a week variations due to the variations of the circumstellar envelope. Observed variability may be explained by a duplicity or variable magnetic field in the circumstellar disk of the star. Difficulties of supposed mechanisms of variability are discussed.

The evolution of a binary in a retrograde circular orbit embedded in an accretion disk

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Supermassive black hole binaries may form as a consequence of galaxy mergers. Both prograde and retrograde orbits have been proposed. We study a binary of a small mass ratio, q, in a retrograde orbit immersed a gaseous accretion disk, focusing on the case where the binary mass ratio is small but large enough to significantly perturb the disk. We develop the theory of type I migration in this case and determine conditions for gap formation finding that when this happens inward migration occurs on a time scale equal to the time required for one half of the secondary mass to be accreted through the unperturbed accretion disk. Accretion rate on to the secondary itself is found to play a minor role for the orbital evolution being of the order of $q^{1/3}$ of that to the primary. We obtain good general agreement between the semi-analytic and fully numerical approaches. We conclude that inward migration induced by interaction with the disk can enable the binary to migrate inwards alleviating the so called final parsec problem. When q is sufficiently small there is no well pronounced cavity inside the binary orbit, contrary to the prograde case. The accretion rate to the secondary does not influence much the binary orbital evolution, but can lead to some interesting observational consequences provided the accretion efficiency is sufficiently large. In this case the binary may be detected as e.g. two sources of radiation rotating around each other.

Thermal radiation of neutron stars with internal heaters

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We discuss thermal structure of neutron stars with internal heat sources in their crust. We analyze spreading of heat from the heat source for different heater's locations, geometries and heat intensities using two and one dimensional cooling codes, and formulate the conditions under which the generated heat can be efficiently transported to the surface and emitted there as intense X-ray radiation. We demonstrate that generated heat mainly propagates radially to the interior of the star and is carried away by neutrino from there. Only a small part of the heat diffuses to the surface and is emmited as thermal radiation. We outline possible applications of the results to young and hot neutron stras, to neutron stars in soft X-ray transients, to magnetars, i.e. warm neutron stars with ultrastrong magnetic filds, high-B pulsars and to so called "hidden" magnetars, i.e. neutron stars with magnetar's magnetic fields screened by a fall-back material after supernova explosions.

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Relative intensities of the hydrogen lines as a tool for diagnostics of the astrophysical plasma

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The hydrogen lines play an important role for diagnostic and modeling of emission regions. In recent years due to the rapid development of infrared astronomy the lines of higher hydrogen series became the objects of the research. After the short review of the published results of the model calculations we present the calculations of relative intensities of lines belonging to Paschen, Bracket and Pfund series. They can be used both for diagnostic of emitting regions, and for determining the extinction for the objects with strong absorption.

Search for the Giant Pulses (GPs) — an extreme phenomenon in radio pulsar emission

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Generally GPs are defined as extremely strong individuals pulses, having a very short duration, power-law distribution of pulse energy/peak flux density. By agreement, the basic properties that distinguish GP from regular pulses are: exceeding of an average pulse more than 30 times and power-law distribution of pulses. It worth noting that regular pulses typically exceed an average pulse no more than 10 times and have a log-normal distribution.

There are about 20 known pulsars with reported GPs. There were no found any combinations of pulsar parameters that could to predict the appearance of GPs from given pulsars. It complicates theoretical description of the phenomenon.

To increase the number of known pulsars with GPs and to build statistics on GPs on the long time intervals we realized a long term session of observations with Large Phase Array (PRAO) at 111 MHz. Several pulsars with individual pulses, which can be probably referred as GPs, were discovered.

We discovered that pulsars B1237+25 and B1133+16 demonstrate strong individual pulses (SIP) with peak flux density exceeding average pulse more than 30 times. Distributions of their SIPs are similar to these of GPs. Earlier in 2003 there were discovered GPs from PSR B1112+50 at 111 MHz. The energy distributions for all these pulsars are similar with that of pulsars B1112+50, B1133+16 and B1237+25 have similar mechanism generation of these strong pulses.

Problems of dualcore galaxies

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No abstract.

V.V. Sobolev and physics of gaseous nebulae

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First works by V.V. Sobolev devoted to research of the gaseous nebulae. He proposed a method for determining the nebula temperature based on the analysis of the energy balance of the electron gas. He also investigated the transfer of L_α and L_c radiation in nebulae and the role of light pressure in their dynamics. The works by V.V. Sobolev was one of the bases for constructing the ionization models of gaseous nebulae. Sobolev method is widely used in solving the problems of radiation transfer in the nebulae. In our report we review the impact of the ideas and methods proposed V.V. Sobolev on both classic and the contemporary researches in the physics of gaseous nebulae.

Molecular clouds dynamics in the Milky Way

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Using 3D hydrodynamic calculations we simulate formation of molecular clouds in the Galaxy. The simulations take into account molecular hydrogen chemical kinetics, cooling and heating processes. Comprehensive gravitational potential accounts for contributions from the stellar bulge, two- and four-armed spiral structure, stellar disc, dark halo and takes into account self-gravitation of the gaseous component. Gas clouds in our model form in the spiral arms due to shear and wiggle instabilities and turn into molecular clouds after $t > 100$ Myr. At the times $t \sim 100 \div 300$ Myr the clouds form hierarchical structures and agglomerations with the sizes of 100 pc and greater. We analyze physical properties of the simulated clouds and find that synthetic statistical distributions like mass spectrum, "mass-size" relation and velocity dispersion are close to those observed in the Galaxy. The synthetic $l - v$ (galactic longitude – radial velocity) diagram of the simulated molecular gas distribution resembles observed one and displays a structure with appearance similar to molecular ring of the Galaxy. Existence of this structure in our modeling can be explained by superposition of emission from the galactic bar and the spiral arms at $3 \div 4$ kpc.

Origin of the isolated neutron star with anomalously long period 6.7 hr.

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The point X-ray source 1E 161348-5055 is observed to produce pulsations with the period of 6.67 hr. The source is associated with the 2000 yr old supernova remnant RCW 103 and is widely believed to be a neutron star. Observations give no evidence for the star to be a member of a binary system. Nevertheless, it resembles an accretionpowered pulsar with the magnetospheric radius ~ 3000 km and the mass-accretion rate $\sim 10^{14}$ g/s. We show that the origin and the current state of the pulsar can be explained in terms of an accretion from a fossil non-Keplerian magnetic disk (magnetic slab) provided the surface magnetic field of the star is about 10^{12} G [1]. The origin and basic parameters of the magnetic slab are briefly discussed.

[1] N.R. Ikhsanov et al., Astrophys. Space Sci., **346**, 105 (2013).

[2] N.R. Ikhsanov, V.Yu. Kim, N.G. Beskrovnaya, Astronomy Reports, **59**, 25 (2015).

Polarimetric properties of icy moons of the outer planets

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The progress in the study of polarization phenomena exhibited by planetary moons is reviewed. Besides previously published data, we focus primarily on the new results of our recent polarimetric observations of the Galilean satellites of Jupiter, bright satellites of Saturn (Enceladus, Dione, Rhea, Iapetus), and the major moons of Uranus (Ariel, Umbriel, Titania, Oberon) at backscattering geometries, including phase angles approaching zero. In addition to a negative branch of polarization, which is typical of atmosphereless solar system bodies (ASSBs), some high-albedo objects, including E-type asteroids, reveal a backscattering polarization feature in the form of a spike-like negative-polarization minimum. These optical phenomena serve as important tests of modern theoretical descriptions of light scattering by regolith surfaces. The polarimetric and photometric behavior of different ASSBs near opposition is highly various. It appears that there is a stratification of the polarization observed for small bodies with their distance from the Sun. The possible reasons for such a stratification will be discussed.

On the development of the asymptotic theory of non-stationary radiative transfer

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The systematic development of the theory of non-stationary radiative transfer began with the work of V.V. Sobolev "On the theory of non-stationary radiation field" published in 1952 (see Astron.Zh., v. 29, iss. 4, pp. 406–414, iss. 5, pp. 517–525). The Laplace transform is used for the solution of the non-stationary radiative transfer equation. As a result of this conversion, the stationary equation is derived, but the included values of absorption coefficient α, the optical distance τ and the single scattering albedo λ change. The solution of the non-stationary problems is obtained by applying the inverse Laplace transform. Later I.N. Minin proposed to use a simple technique for inverting of the Laplace transform in the case where the single scattering albedo is close to unity. This technique is applied in several articles to obtain asymptotic expressions for characteristics of non-stationary radiation field at the large optical distances from sources of radiation at $1 - \lambda \ll 1$. In particular, this method was used for finding the asymptotic expressions for the mean intensity and flux of non-stationary radiation at various space distributions of the light sources.

Stability of AGN jets and the Fanaroff-Riley division

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In stark contrast to their laboratory and terrestrial counterparts, cosmic jets appear to be very stable. They are able to penetrate vast spaces, which exceed by up to a billion times the size of their central engines. We propose that the reason behind this remarkable property is the loss of causal connectivity across these jets, caused by their rapid expansion in response to fast decline of external pressure with the distance from the "jet engine". In atmospheres with power-law pressure distribution, the total loss of causal connectivity occurs when the power exceeds the value of two — the steepness which is expected to be quite common for many astrophysical environments. Cosmic jets may become globally unstable when they enter flat sections of external atmospheres. We propose that the Fanaroff-Riley morphological division of extragalactic radio sources into two classes is related to this issue. In particular, we argue that the low power FR–I jets become re-confined, causally connected and globally unstable on the scale of galactic X-ray coronas, whereas more powerful FR–II jets re-confine much further out, already on the scale of radio lobes, and remain largely intact until they terminate at hot spots. Using this idea, we derived the relationship between the critical jet power and the optical luminosity of the host galaxy, which is in a very good agreement with the observations.

Structure of galaxy groups and clusters and measurement their masses

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The mass function of galaxy clusters is sensitive to the cosmological parameters, turning the measurement of their accurate masses a challenging task. We carried out the measurement and comparison of the masses obtained by different methods for a sample of 29 of groups and clusters of galaxies ($z < 0.1$). To measure the dynamic mass from the one-dimensional dispersion of line-of-sight velocities for virialized regions of radii R_{200} and R_e is used archival data SDSS DR7. Our method of selection of groups or clusters and determination of the effective radii of galaxies systems from the cumulative distribution of the number of galaxies depending on the squared clustercentric distance allowed us to estimate masses $M_{1/2}$ (within R_e) which are related to the masses contained within the radius R_{200}: $M_{200} \sim 1.65\, M_{1/2}$. A comparison of the inferred dynamic masses and the hydrostatic masses determined from the radiation of thot gas in galaxy groups and clusters (based on published data) led us to conclude that the inferred masses for the main sample of 21 groups and clusters agree of masses to within 12%. These sample also obey the relation $M_{X,200} \sim 1.65\, M_{1/2}$. For the remaining eight systems, which are mostly located in the region of the Hercules supercluster, the discrepancy between the hydrostatic and the dynamic masses amounts to 2σ.

The fundamental plane of clusters and groups of galaxies

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Gravitationally bound systems such as early types galaxies, globular clusters of stars, and clusters of galaxies lie on the fundamental plane (FP), binding size (effective radius), luminosity (average surface brightness) and velocity dispersion. To determine these parameters for 94 clusters and groups of galaxies we constructed cumulative distribution of the total number of galaxies as a function of squared clustercentric distance. Such profiles of clusters or groups galaxies (Kopylov, Kopylova, 2015, AstBu, V. 70, Iss. 3) allowed us to identify the virialized part of the systems, to determine the corrected for background luminosity and effective radius within which contains half of the total luminosity. The work is done on archival data SDSS, 2MASX, NED catalogues. Obtained by the method of least squares the FP of clusters and groups of galaxies in r-band is:

$$\log R_e \text{ (kpc)} = 1.02^{\pm 0.06} \log \sigma - 0.55^{\pm 0.04} \log\langle I_e\rangle - 0.60^{\pm 0.10}.$$

The coefficients on $\log\sigma$ and $\log\langle I_e\rangle$ to 1.5 times less than that obtained for the FP of early-type galaxies. A comparison with the FP of clusters of galaxies (sample WINGS, D'onofrio et al., 2013, AN, 334, 373) showed that the coefficients on $\log\sigma$ is almost the same, while on $\log\langle I_e\rangle$ differ by about 1.9 times.

The study of the long-term spectral variability of Ae Herbig star HD 190073

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We present the results of high-resolution ($R = 20000$) spectral monitoring of Ae Herbig star HD 190073 in the region of H_α emission line, He I 5876 line and NaI D resonance doublet lines. Theses results show the parameters of spectral lines vary on the long-term scale. The changing of He I emission is anticorrelated with variations of NaI D lines. The obtained results allow us to conclude that the reason of this variability is caused by the changing of the physical and kinematics conditions in the circumstellar disc of HD 190073. We believe that the cause of the observed variability is the presence of low-mass component in the neighborhood of HD 190073.

Diffuse interstellar bands approaching centenary

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In 1921 M.L. Heger published the discovery of two reasonably broad stationary (non-stellar) features discovered in the spectra from the Lick Observatory in the fall of 1919. The features are centered near 5780 and 5797 Å. Since that time they remain unidentified; only the list of known diffuse interstellar bands has grown up to more than 400 entries. They are apparently carried by more than one substance; very likely some complex, carbon-bearing molecules are responsible for the diffuse band spectrum. Diffuse bands are concentrated in yellow-red part of the visual range but some of them are observable in violet or near infrared. Very recently (July 15) a group of Swiss experimentalists claimed identification of two, near infrared diffuse bands (9577 and 9632 Å), as being carried by the cation of C_{60} (the soccer ball). The talk presents the most important observational facts concerning diffuse bands (the problems of their central wavelengths, profile shapes, strength ratios etc.) and the comparison of the recent laboratory spectrum of C_{60}^{+} with the recent observational data. Apparently after almost 100 years of investigations the origin of diffuse bands remains a fascinating puzzle of astrophysics.

Testing the variation of fundamental constants by astrophysical methods: overview and prospects

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By measuring the fundamental constants in astrophysical objects one can test such basic physical principles as space-time invariance of physical laws along with probing the applicability limits of the Standard Model of particle physics.

The latest constraints on the fine structure constant α and the electron-to-proton mass ratio μ obtained from observations at high redshifts and in the Milky Way disk are reviewed. In optical range, the most accurate measurements have already reached the sensitivity limit of available instruments, and further improvements will be possible only with next generation of telescopes and receivers. New methods of the wavelength calibration should be realized to control systematic errors at the sub-pixel level.

In radio segment, the main tasks are the search for galactic and extragalactic objects suitable for precise molecular spectroscopy as well as high resolution laboratory measurements of molecular lines to provide accurate frequency standards.

The expected progress in the optical and radio astrophysical observations is quantified.

Superflares on late-type stars: radiative losses and other problems of modeling of the gas-dynamical processes

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We discuss briefly new observations of superflares on G main-sequence stars discovered in optics with the Kepler mission. In the framework of a solar flare paradigm, we associate the origin of the strong optical continuum emission with an acceleration of particles of their subsequent impact on dense layers of the chromosphere and the upper photosphere. One of basic problems in gas-dynamical modeling of large flares is knowledge of radiative losses. Using the radiative transfer methods developed by Sobolev and his colleagues, we calculated first a version of the radiative losses for optical thin and thick layers in the L_α line. These results applied during more than 35 years, and only now require elaboration of this model. First, we were carried out the new modeling of the previous formulation of the problem for a solar flare applying new algorithm and parallelization with three IZMIRAN computers. We have reproduced those results and realized that conditions in the basic source of the flare optical emission (a low-temperature condensation) are strongly non-equilibrium. We analyze conditions of formation of the hydrogen emission and its features behind the shock front in $2T$-approximation with the aim to apply these results in solution of the radiative gas-dynamics equation system. For extreme flares, we discuss problems of limitation of the thermal flux and an influence of the return current as well. We propose a preliminary model of superflares and some consequences.

X-ray binary systems through the eyes of INTEGRAL

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The review of the current results obtained by the INTEGRAL observatory for X-ray binary systems is presented. During dozen years of the operation the observatory discovered new types of X-ray binary systems, like supergiant fast X-ray transients, deeply obscured sources, has permitted studies of cyclotron resonance scattering features with unprecedented resolution for several persistent and transient pulsars. Deep observations of the galactic plane allowed us to study also global properties of different populations of X-ray binary systems. In particular, we have constructed luminosity functions of low and high mass X-ray binaries (HMXBs) down to the luminosities of $\sim 10^{34}$ erg/s, measured their spatial distribution in the Galaxy, revealed a direct correlation between the spatial density distribution of HMXBs and the star formation rate distribution.

LBV stars HD 168625 and HD 168607 and their environment

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The results of spectral monitoring of two blue hypergiants HD 168625 and HD 168607, and results of spectral studies of stars in the M17 association, which includes these hypergiants, are presented.

Modeling of spectral variability of Romano's star

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We present results of investigation of spectral variability of one of the most interesting massive stars, V 532, or Romano's star, located in the M 33 galaxy. Using CMFGEN code we estimated parameters of stellar atmosphere and found that during last ten years bolometric luminosity of the star changes synchronously with stellar magnitude. Our calculations argue in favor of the hypothesis of a post-LBV status of V 532.

Non-LTE line formation for Al I and Si I in stellar atmospheres, with applying accurate data on inelastic collisions with neutral hydrogen atoms

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Accurate determination of spectroscopic stellar atmosphere parameters and chemical abundances is based on non-LTE line formation. The main uncertainty in final non-LTE results for the F-G-K type stars, in particular, metal-poor ones is due to poorly known inelastic collisions with H I atoms. This problem is debated for decades, however, accurate data are still missing for most chemical species. In this study we use the rate coefficients for Al+H and Si+H collisions calculated in the Born-Oppenheimer approximation. We show that including collisions with H I atoms affects the statistical equilibrium of Al I and Si I and their line strengths compared with the case of pure electronic collisions. The non-LTE abundance corrections for Al I 6696-98, 7835-36, and 8772-73 Å become smaller, providing consistent within ±0.1 dex abundances from the resonance and subordinate lines in the investigated metal-poor stars. Ignoring collisions with H I atoms produces a factor of three larger scatter of data. For Si I the departures from LTE were found to be small for the mildly metal deficient stars.

Magnetic field distribution for massive stars

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We present a model of the magnetic field evolution for main sequence (MS) OBA stars allowing to find the magnetic field distribution (MFD). The model consist of population synthesis code, which allows to follow the evolution of magnetic stars and their magnetic fields from the pre-main sequence (PMS) stage up to TAMS stage. We assume that magnetic fields in massive stars are decreasing with time, with dissipation rate proportional to the MS lifetime. The MFD at ZAMS is supposed to be log-normal. As we show, this kind of distribution may be obtained by simple dynamo-action simulations at PMS stage. Our calculations demonstrate that the shape of resulting MFD is highly dependent on the rate of magnetic field dissipation. Our model was used for analysis of the real MFD of OBA stars, obtained from the catalogue of magnetic field measurements by Bychkov et al. (2009) and from the later works. We find that evolution of magnetic fields is slow, or nearly absent, to fit the real MFD. The shape of the real MFD has no indications of the "magnetic desert", previously suggested by Auriere et al. (2007). Basing on this finding we argue that the observed fraction of magnetic stars is determined by physical conditions at early stages of stellar evolution.

Some spectral characteristics of symbiotic stars AG Dra and CH Cyg in their active phases

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The spectral observations were performed by using of echelle spectrograph of Cassegrain focus of the 2-m telescope at Shamakhy Astrophysical Observatory.

In 2006, for a time interval of about 100 days, the brightness of star AG Dra increased about 1^m in filter V. As a result of analysis of spectrum of star AG Dra received during increasing of brightness the following spectral features of this star have been revealed: the increasing and decreasing of equivalent width of H_α, H_β emission lines and of absorption lines correspondingly were revealed; at the peak of the flare, only lines He I λ5876 Å and λ5016 Å, having a relatively low excitation potentials, shows the profile of the type P Cyg; the intensity of He I λ5412 Å line decreases and disappears in the maximum of flare.

During 6 hours in one night (07/15/2015) 14 echelle spectrograms of symbiotic star CH Cyg with the exposure time of 20 minutes were obtained. H_α and H_β lines shows a two emission component structure with the absorption line in the center. The intensity of blue emission component (V) changes strongly during night; the value of ratio V/R of line H_α decreases from 0.93 to 0.49 and then increases to a value 0.97. The ratio V/R of H_β reduced from 1.0 to 0.63, and then rises to the level of 1.06. During the night, the equivalent width of the line He II λ5876 Å, and blue components of the H_α line varies approximately two times.

Electromagnetic scattering by discrete random media

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While it is generally recognized that the Maxwell equations control the transport of electromagnetic energy in macroscopic particulate and heterogeneous media, direct computer solutions of these equations for such media had been impracticable until quite recently. This has led to a widespread use of phenomenological approaches and heuristic effective-medium approximations in situations when their very applicability can be questioned. This situation is now changing owing to the availability of efficient computer solvers of the Maxwell equations applicable to macroscopic multi-particle groups. In fact, a new branch of statistical electromagnetics has emerged wherein the scattering of light (and other electromagnetic radiation) by discrete and discretely heterogeneous random media is modeled directly by using numerically exact computer solutions of the Maxwell equations. In this review we summarize these recent developments and discuss how they establish a mesoscopic bridge between the macrophysical regime of radiative transfer, weak localization, and effective-medium approximations on one hand and the microphysical regime of Maxwell's electromagnetics on the other.

The calculation of parameters for supernovae employing AZT-8 and LX200 telescopes

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Photometric and polarimetric observations with telescopes AZT-8 and LX200 were performed for the three SNe: SN2012aw (type IIP), SN2013ej (type IIP), SN2014J (type Ia). As a result of observation treatment, a number of parameters were calculated: the mass of nickel ejected in the explosion, the mass of the ejected shell, the radius of the star-progenitor, the temperature and a photosphere radius distribution depending on the time, relative distribution of energy in the spectrum, the explosion energy. Polarimetric data have provided the information on explosion asymmetry. The parameters obtained were analyzed and compared with the data published in literature on these SNe and other SNe of the same type.

Continuum and line emission of flares on red dwarf stars

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The emission spectrum has been calculated of a homogeneous pure hydrogen layer, which parameters are typical for a flare on a red dwarf. The ionization and excitation states were determined by the solution of steady-state equations taking into account the continuum and all discrete hydrogen levels. We consider the following elementary processes: electron-impact transitions, spontaneous and induced radiative transitions, and ionization by the bremsstrahlung and recombination radiation of the layer itself. The Biberman–Holstein approximation was used to calculate the scattering of line radiation. Asymptotic formulae for the escape probability are obtained for a symmetric line profile taking into account the Stark and Doppler effects. The approximation for the core of the H_α line by a Gaussian curve has been substantiated.

The spectral intensity of the continuous spectrum, the intensity of the lines of the Balmer series and the magnitude of the Balmer jump have been calculated. The conditions have been determined for which the Balmer jump and the emission line intensities above the continuum decrease to such low values that the emission spectrum can be assumed to be continuum as well as the conditions at which the emission spectrum becomes close to the blackbody.

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Carbonaceous dust emission and evolution in star-forming complexes

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Variations in the mid-infrared emission in similar objects, like galaxies or star-forming complexes, likely in most cases arise from differences in the evolution of dust grains responsible for this emission. It is believed the small aromatic carbonaceous grains contribute significantly to this emission ($3 \div 20$ μm). To understand how their evolution proceeds a model is needed that would incorporate all significant processes of dust formation and destruction. The goal of this work is to reproduce the life of a star-forming complex and to look for factors which are most crucial for the evolution of aromatic grains and mid-IR spectral energy distributions (SEDs).

We consider a number of relevant evolutionary processes, including photoprocessing of carbonaceous grains, erosion by the most abundant ions (H, He, C) and electrons, fragmentation due to collisions between grains. Small grains are destructed by photons and fast ions, but they also form in grain-grain collisions due to fragmentation of larger grains. These small grains, being continuously replenished, are irradiated by ultraviolet field and aromatised. The balance of all of these processes is controlled by environment conditions, in particular, velocity of turbulent motions, number of massive stars, metallicity, etc. We model all these processes for conditions corresponding to giant H II complexes and look for variations of infrared SEDs during evolution.

X-ray pulsars in a wide luminosity range

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A picture of X-ray pulsars behavior in a wide luminosity range will be presented. We will start with low luminosity case, when the accretion leads to hot spots on the neutron star surface, continue with high mass accretion rates, when the luminosity exceeds the critical value and radiation pressure results in accretion columns above the stellar surface, and finish with the maximum accretion luminosity. It will be shown that the luminosity of order 10^{40} erg/s can be provided, which explains connection between X-ray pulsars and ultraluminous X-ray sources.

Synchro-self-Compton mechanism

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It is well known that synchro-self-Compton mechanism is a basic mechanism which is used for interpretation of observable spectra of relativistic astrophysical objects. These objects are active galactic nuclei (AGN) and compact sources of stellar masses, jets and coronas forming around them and other. In the talk the description of the mechanism is given. Then the methods are proposed for calculation of radiation spectra of mildly relativistic electron gas and the averaging the redistribution function of the Compton scattering on the azimuth.

According obtained formulas suitable computer codes are written.

V.V. Sobolev and Radiative Transfer Theory

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The basis of the theory was laid before V.V. Sobolev but it was he which gave the dominant contribution to development of analytical radiative transfer theory.

The main stimulus for Sobolev was solving problems arising in astrophysical observations. He proposed the approximation of complete frequency redistribution (CFR) for correct explanation of line profiles in stellar spectra particularly the residual intensities of absorption lines and two-humped profiles of emission lines. The Sobolev method of calculation of populations of atomic levels in expanding and nonplane media are widely used till now. He proposed effective method for solving the problems of anisotropic scattering, began studying of time-depending scattering and scattering of polarized light (the Chandrasekhar–Sobolev effect). He used his researches for explaining observable phenomena.

Another motive for developing the theory for Sobolev was aspiration to beauty. He repeated the phrase "In beautiful theory the verity is shining". Therefore he tried to bring to possible ideal. He introduced into theory the probabilistic interpretation of scattering process which allowed significantly simplify calculations. He created the exact theory of integral equations describing multiple scattering of line radiation with CFR (famous Resolvent Method), reduced the calculation of anisotropic scattering to finding of the minimal number of basic functions. So V.V. Sobolev in fact completed the theory which then was introduced into accessible complexes of computer codes.

Simulation of CH_3OH masers: accelerated lambda iteration method and Sobolev approximation

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The model is presented of the CH_3OH maser. Two techniques are employed for the calculation of molecule level populations: the accelerated lambda iteration method and large velocity gradient approximation (Sobolev approximation). Two methods give similar results when the gas velocity change across the cloud due to velocity gradient is much larger than the Doppler line width. As originally formulated by V.V. Sobolev [1,2], the large velocity gradient approximation for line formation problems ignores the effect of continuous opacity. Hummer and Rybicki generalized the large velocity gradient approximation to include the effects of continuous opacity in the resonance region [3]. We show that the dust emission play a significant role in determining level populations of the CH_3OH molecule in maser clouds. The physical conditions necessary for the generation of strong CH_3OH maser emission are discussed.

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On some directions of development of the radiative transfer theory

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We review some works performed in the Byurakan observatory in the theory of radiative transfer. These works develop Ambartsumian's ideas on the layers addition laws and the principle of invariance. The methods based on them have been extremely flexible in applications and efficient in numerical calculations. In this connection, the necessity appears to elucidate their place and significance in the modern transfer theory. We discuss the results obtained in two directions. The first of them concerns the variational formalism which being applied to the transfer equations leads to the principle based on the translational transformation of the optical depth. The modern methods of functional analysis make it possible to derive Lagrangians and conservation laws for different transfer problems of astrophysical importance. We find out a group of problems frequently encountered in astrophysical applications which are related with each other and are reducible to solution of the source-free problem. The second direction of investigations is devoted to the group-theoretical description of the radiation transfer in inhomogeneous atmospheres in the general case when the spatial and frequency distributions of the radiation field are taken into account. We introduce the concepts of groups of composition of media with different optical and physical properties and groups of translation of optical depths. The representations of the proper groups are found. In the limiting case when the thickness of the supplemented layer tends to zero we are led to the Lie groups which generate the classical transfer equations, on the one hand, and the equations of invariant imbedding, on the other. In both cases the standard boundary-value problems are reducible to initial-value problems which are better adapted to solution on the modern electronic machines.

Investigation of the parameters of two massive X-ray binary systems

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We investigate parameters of two high-mass X-ray binary systems IGR J17544-2619 and IGR J21343+4738 discovered by INTEGRAL space observatory by using optical data of Russian Turkish Telescope (RTT-150).

Long-term optical observations of X-ray binary systems IGR J17544-2619 and IGR J21343+4738 were carried out in 2007–2015. Based on the RTT-150 data we estimated orbital parameters of these systems and calculated mass function. We have modeled the blend profile of lines He I 6678 Å and He II 6683 Å in spectra of IGR J17544-2619. The following parameters of the optical component's atmosphere are obtained: $T_{\rm eff} = 34000$ K, $\log g = 3.95$, [He/H] = 0.4, [M/H] = 0.5, $V_{\rm rot} \sin i = 165$ km/s. These parameters correspond to the spectral class O9 IV–V with a mass of about 23 $\mathfrak{M}_\odot$.

IGR J21343+4738 is a binary system consisting of a X-ray compact object and optical Be-stars. Variations of Be-star brightness during 2006–2015 correlated with changing of the equatorial disk size. For the construction of the radial velocity we used profiles of the helium lines. Based on these RTT-150 observations a possible orbit has the following parameters: the period of $P = 40.00 \pm 0.06$ days, eccentricity $e = 0.75 \pm 0.1$, semiamplitude of the radial velocity curve $K = 14 \pm 3$ km/s.

Optical continuum of powerful solar and stellar flares

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We briefly discuss the pioneer works by Grinin and Sobolev concerning the relation between the optical continuum of the flare emission and the accelerated particles flux. Subsequently, consideration of this idea required the modeling of the gas-dynamical response of the chromosphere to the impulsive heating. We present the calculation of the emission spectrum of the hydrogenic plasma of this condensation. It is shown that such a model can explain the line emission of hydrogen and the continuous recombination emission. In the visible region this continuum appears to be weak: the emission contrasts do not exceed 5% – 7% even in the case of the most powerful heating flux. But the contrast can reach as much as 15% – 20% in some cases. In order to explain so large values, one has to introduce the additional heating of the upper photosphere, the nature of which is unclear. We shortly discuss Solar observations of "black light flares", which were predicted by Grinin and Sobolev for red dwarf stars.

Moving inhomogeneous envelopes of stars

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Massive stars are extremely luminous and drive strong, winds, blowing a large part of their matter into the galactic environment before they finally explode as a supernova. Quantitative knowledge of the action of massive stars is prerequisite to understand our Universe. Massive stars have been studied so far under the assumption that their winds are homogeneous and stationary, largely relaying on Sobolev's approximation. Observations with the newest instruments, together with progress in model calculations, ultimately dictate a cardinal change of this paradigm: stellar winds are highly inhomogeneous. Hence, we now advancing to the new stage in our understanding of stellar winds. Using the foundations developed by V.V. Sobolev and his school, we now updating and further develop the stellar spectra analysis techniques. In this talk I will review and present new multiwavelength observations which elucidate the physics of stellar winds. I will present most recent and sophisticated models of radiation transfer in inhomogeneous stellar winds. Our new description of radiative transfer in clumped winds is an important advance because it allows to waive some severe approximations about the properties of stellar winds. Applications of this new technique improve the empirical in mass-loss rate diagnostics, and explain various observations obtained with the most advanced telescopes on ground and in space.

Molecular line emission in protostellar objects

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Observations of molecular line emission (by CO, CS, HCO+, N_2H+, etc.) is a powerful tool to study the physical conditions in the objects associated with star formation process. Among these (protostellar) objects are the prestellar and protostellar cores of molecular clouds, protoplanetary disks, H II regions around young massive stars. However, the molecular line formation is a complicated process depending on many physical factors such as non-homogeneous density and temperature distributions, chemical stratification, complex kinematic structure within these sources. Thus, to extract the physical structure from the observed molecular spectra maps we need to adopt/develop detailed chemo-dynamical and radiative transfer models. In the talk, we discuss the aspects of the self-consistent modeling of protostellar cores and protoplanetary disks. In the frames of the presented models, we calculate not only the density, thermal and chemical structure of these objects but their molecular spectra maps for direct comparison with observations. We show the effects of the main physical factors which affect the molecular line profiles and should be taken into account during the direct comparison between the models and observations.

Reflectionless kink waves in the coronal plasma

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The vertical propagation of kink waves in strong inhomogeneous plasma (solar atmosphere) is studied in the framework of the linear theory. It is shown that the governing equations under certain conditions can be reduced to the Klein-Gordon equation with constant coefficients. Its solutions describe traveling monochromatic waves with a variable amplitude and wavenumber that are not reflected in the solar atmosphere despite its strong inhomogeneity. Certain conditions of this transformation describe the set of the vertical profiles of magnetic field and density. The wave energy flux at such reflectionless profiles is constant, providing the possibility of the energy transfer to high altitudes.

We consider a coronal loop of half-circle shape embedded in an isothermal atmosphere. We show that non-reflective kink wave propagation is possible for a particular dependence of the loop radius on the distance along the loop. A viable assumption that the loop radius increases from the loop footpoint to the apex imposes a lower limit on the loop expansion factor, which is the ratio of the loop radii at the apex and footpoints. This lower limit increases with the loop height. However, even for a loop that is twice as high as the atmospheric scale height, it is small enough to satisfy observational constraints. Hence, we conclude that non-reflective propagation of kink waves is possible in a fairly realistic model of coronal loops.

On linear properties of anon-linear problem of radiative transfer

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Introduction of Ambartsumian's layers adding method and the probabilistic approach of Sobolev significantly extended the capabilities of the methods of the transfer theory. The first of them was applied also to non-linear problems of radiative transfer, where the characteristics of the scattering and absorbing medium depend on the density of radiation diffused in it. The second has not applied to non-linear problems as far as the scattering and absorbing properties of a medium are affected by characteristics of an ensemble of photons but not by a single photon. A complexity of non-linear transfer problems dictates the need for seeking simplified methods of solution particularly by involving exactly or approximately some characteristics of linear problems like the method of self-consistent optical depths or the layers adding method in approximation of the perturbation theory, etc. In the present report, we revealed an "exact linear structure" in the non-linear transfer problems. It is shown that in the case where both boundaries of one-dimensional anisotropic medium of finite geometrical thickness are illuminated by intense fluxes of radiation for a given state of excitation the intensities of radiation exiting medium through both boundaries can be derived by constructing a simple linear combination of probabilities we introduced for the reflection and transmission of a single photon incident on one or another boundary. We derived the exact formulas for the non-linear addition of layers for introduced probabilities dependent on both external fluxes, which retain the general structure of exact formulas of the linear addition. A complete set of differential equations of invariant imbedding is obtained.

Signatures of magnetospheric accretion in magnetic Herbig Ae stars

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Optical and near-IR observations of several magnetic Herbig Ae stars have been used to investigate the character of their accretion disk/star interaction. Spectral observations were carried out with the ISAAC and X-shooter spectrographs installed at the VLT-8m (ESO, Chile) as well as with other spectrographs of several observatories such as OHP,LNA, Crimean AO. The spectroscopic data were obtained in the He I 5876, 10830 and P_γ lines formed in the accretion region of the program objects. We found that the temporal behaviour of the diagnostic lines of some objects can be explained by a rotational modulation of line profiles generated by local accretion as well as outflowing gas. This result is in good agreement with the predictions of themagnetospheric accretion model. Three distinct periods of short-term variability of HD 104237 were revealed. The first of them (5.37 days) was identified as the rotation period of the star. The two other periods were assumed to be a result of two rotating stream-like inhomogeneities in outflowing gas originating in the disk. The inclination angle of HD 104237, $i = 21^\circ \pm 4^\circ$, was determined. An additional analysis of HD 190074 allows to suspect that the magnetic field of the object is likely more complex than a simple dipole and contains a circumstellar component.

A viscous-convective instability in laminar Keplerian thin discs

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Using the anelastic approximation of linearized hydrodynamic equations, we investigate the development of axially symmetric small perturbations in thin Keplerian discs. The sixth-order dispersion equation is derived and numerically solved for different values of relevant physical parameters (viscosity, heat conductivity, disc semithickness and vertical structure). The analysis reveals the appearance of two overstable modes which split out from the classical Rayleigh inertial modes in a wide range of the parameters in both ionized and neutral gases. These modes have a viscous-convective nature and can serve as a seed for turbulence in astrophysical discs even in the absence of magnetic fields.

On the dependence of the X-ray continuum variations with luminosity in accreting X-ray pulsars

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Using RXTE/ASM archival data, we investigate the behavior of the spectral hardness ratio as a function of X-ray luminosity in a sample of six transient X-ray pulsars (EXO 2030+375, GX 304–1, 4U 0115+63, V 0332+63, A 0535+26 and MXB 0656–072). In all sources we find that the spectral hardness ratio defined as $F_{5\div12\ \mathrm{keV}}/F_{1.33\div3\ \mathrm{keV}}$ increases with the ASM flux ($1.33 \div 12$ keV) at low luminosities and then saturates or even slightly decreases above some critical X-ray luminosity falling into the range $\sim (3 \div 7) \cdot 10^{37}$ erg/s. Two-dimensional structure of accretion columns in the radiation-diffusion limit is calculated for two possible geometries (filled and hollow cylinder) for mass accretion rates $\dot{M}$ ranging from 10^{17} to $1.2 \cdot 10^{18}$ g/s. The observed spectral behaviour in the transient X-ray pulsars with increasing $\dot{M}$ can be reproduced by a Compton saturated sidewall emission from optically thick magnetized accretion columns with taking into account the emission reflected from the neutron star atmosphere. At $\dot{M}$ above some critical value $\dot{M}_{\mathrm{cr}} \sim (6 \div 8) \cdot 10^{17}$ g/s, the hight of the column becomes such that the contribution of the reflected component to the total emission starts decreasing, which leads to the saturation and even slight decrease of the spectral hardness. Hollow-cylinder columns have a smaller height than the filled-cylinder ones, and the contribution of the reflected component in the total emission does not virtually change with $\dot{M}$ (and hence the hardness of the continuum monotonically increases) up to higher mass accretion rates than $\dot{M}_{\mathrm{cr}}$ for the filled columns.

The importance of time-dependent hydrogen ionization in the modeling of supernovae of type IIP

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Utrobin and Chugai [1] have pointed out the importance of time-dependent kinetics for the explanation of the hydrogen lines (e.g. H_α) at any time after the explosion of SN 1987A on the photospheric stage.

The same conclusion was confirmed for SN 1999em by Utrobin [2]. The importance of time-dependence of number densities later than a few weeks after the explosion was found by Dessart, Hillier [3] for SN 1999em with the program CMFGEN. De et al. [4] found, using the software package PHOENIX, that the kinetics is important only in the first days after the supernova explosion. Moreover, they found an influence of the total number of levels in the model hydrogen atom and the importance of account of the fine structure for the determination of the recombination time to the main level. Thus, the conclusions of different research groups are still at odds. This report tries to clarify this ambiguity with a help of new developing code LEVELS.

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Atmospheres and radiating surfaces of neutron stars with strong magnetic fields

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Modern space telescopes have provided a wealth of valuable information on thermal radiation of neutron stars which, when properly interpreted, can elucidate the physics of superdense matter in the interior of these stars. Strong magnetic fields profoundly change the equation of state and radiative opacities in the surface layers of neutron stars and thus affect their thermal spectra. Theory of these effects is reviewed in the talk, including the conventional models of deep (semi-infinite) atmospheres, models of "naked" neutron stars with condensed radiative surfaces, and "thin" (finite) atmosphere models, with examples of application of the theory to tentative interpretations of some observed neutron-star thermal spectra.

Accretion and outflow activity on the late phases of PMS evolution. The case of RZ Piscium

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The ratio between the corotation and truncation radii is the crucial parameter on the Pre Main Sequence evolution stage which determines the relation between mass accretion and outflow. This ratio depends on several parameters, in particular it is inversely proportional to the accretion rate. When this value is low the truncation radius significantly exceed the radius of corotation. In this case the outflow in propeller regime is realised. We consider the observational properties of this mechanism in the case of post T Tauri star RZ Psc. We argue that the propeller regime of accretion is realized also in some other young stars.

Radiative mechanisms of accreting black holes

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I will review our efforts to understand how accreting stellar-mass black hole radiate. I will discuss observations of black holes from optical to the gamma-rays as well as the theory behind the broadband spectra. I will also relate the observed spectral properties to the timing characteristics. I will show that in the hard state most of the available data can be explained within a framework of hot inner accretion flow.

Dust in outer layers of B5 globule

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The properties of dust in dark clouds are still not well understood. Recent studies of extinction law, scattered light and submm emissivity have inferred changes in dust properties with an increase of depth inside a cloud (e.g., Foster et al., 2013). However, there were doubts that the wavelength dependence of polarization of background stars might provide useful information on the size of grains in such clouds (e.g., Andersson et al., 2015).

We present the results of UBVRI polarimetric observations of about 30 stars in a vicinity of the well-studied Bok globule B5. Several of the stars are seen through the globule halo and even outer layers with A_V as large as 3^m, others are field stars close to the globule. For nearly all the stars, we have determined the wavelength of polarization maximum $\lambda_{\max}$ with a good accuracy. Using the spectral classes of the stars obtained either from spectra or from photometry in the Vilnius system and more seldom in 2MASS bands, we have estimated the distance and visual extinction to the stars. A comparison with different maps of B5 has shown that $\lambda_{\max}$ well correlates with $E(B-V)$, i.e. the depth in the cloud. We conclude that multicolor polarimetry of background stars can be a useful tool to characterize dust in halo and outer regions of dark clouds.

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Low-energy inelastic magnesium-hydrogen collisions

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Available quantum calculations of cross sections for inelastic processes in Mg+H and Mg^++H^- collisions are analyzed. It is shown that cross sections with large values are calculated with high accuracy. The corresponding processes are of interest in astrophysics. Inelastic Mg+H collisions are required for non-LTE stellar atmosphere modeling. In the present work, available quantum calculations of cross sections in inelastic Mg+H collisions are analyzed including ones based on improved quantum-chemical data. The calculations include all transitions between the nine lowest adiabatic $MgH(^2\Sigma^+)$ molecular states, with the uppermost of those diabatically extended to the ionic molecular state in the asymptotic region. Calculations also include transitions between five lowest adiabatic $MgH(^2\Pi)$ molecular states. The inelastic cross sections with large values are stable with respect to different calculations, while cross sections with small values are rather sensitive to amount of channels taken into account.

It is worth to point out that all nonadiabatic nuclear dynamical calculations have been performed by means of the reprojection method in the framework of the standard Born-Oppenheimer approach, which is known to provide reliable physical results.

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Applications of General Invariance Relations Reduction Method to solutions of radiation transfer problems

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On the basis of analysis and generalization of classical works on radiation transfer theory (RTT) and application of invariance properties with respect to operations of association, imbedding, decomposition and synthesizing the general invariance relations reduction method (GIRRM) was proposed in 2010 in details. To illustrate the possibilities of GIRRM a number of results obtained by this method for the case of turbid media of various configurations are presented in the report. Firstly classical asymptotic formulas obtained in a convenient form by Sobolev V.V. for the reflection function averaged azimuthally and brightness coefficients , as well as for the plane and spherical albedo will be strictly substantiated using GIRRM. Sobolev V.V. obtained them, using strict relations and some hypotheses on the structure of the asymptotic expressions. However, it should be noted that a three-term asymptotic expression of plane albedo obtained rigorously by the help of GIRRM for the case of nearly conservative scattering only partially coincides in the form with the same asymptotic expression obtained by Sobolev V.V. Nevertheless, the theoretical analysis and a series of numerical experiments have not revealed differences between these asymptotic expressions. Therefore, it can be assumed that the above hypotheses do not lead to any inaccuracies. It should be emphasized that all the quantities in the asymptotic expressions obtained by GIRRM can be calculated for an arbitrary phase function with the help of efficient numerical algorithms. Secondly it will be shown that all of the above-mentioned and other characteristics of radiation fields in plane-parallel turbid media for the case of any single scattering albedo and for any phase function can be calculated using the basic ideas and constructions of GIRRM. It should be noted that all these solutions and representations in contrast to ones constructed within the framework Case's and other methods are suitable in obtaining numerical results. Thirdly a number of multi-dimensional boundary-value problems for scalar RTE that can be solved effectively for the case of an arbitrary phase function and turbid media of various configuration will be outlined briefly in the report.

Spectral variability of the UX Ori type star — WW Vul

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We present the results of our studies of some spectral characteristics in the spectrum of WW Vul based on our spectroscopic observations performed with the aid of 2-m telescope at the ShAO of NAS of Azerbaijan, in 2006 – 2010. Our spectroscopic observations were carried out before (2006 – 2008) and after (2010) the unusual eclipse detected in the V — band light curve of WW Vul. The difference has been found out in the regime of variability in the profile of H_α emission line in the spectrum of UX Ori type star WW Vul in 2006 and within 2007 – 2010-th years. In August 2006, the line H_α in the spectrum of WW Vul appeared as two component emission profile with the ratio of $V/R \approx 1$. Apparently, in the behavior of the variability the dominant role belongs to the rotation of the accretion disk. Starting in 2007 the additional mechanism appears alongside with rotation of accretion disk leading to the rapid variability of the physical condition in the area where H_α line is formed. The magnetic field in the accretion disk and/or on the stellar surface, which determines the character of interaction between the star and its environment, can be such a mechanism. The behavior of the H_α emission line in the spectrum of WW Vul qualitatively agrees to this photometric variation, because almost all parameters of the H_α profile change the direction of their variability beginning from 2007 – 2008.

Astrophysical investigations based on RTT–150 observations

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The 1.5-meter Russian-Turkish telescope (RTT–150), equipped by modern scientific instrumentation (CCD-photometers, spectrometers), participates in international programs of ground support of orbital space Observatories (INTEGRAL, SWIFT, PLANCK) for optical identifications, spectral classification of detected sources (active galactic nuclei , close binary systems, clusters of galaxies, etc.). In particular, these observations aimed at determinations of their physical properties, the construction of the light curves of optical afterglows of γ-ray bursts and others. This report will provide examples of researches carried out with the help of the RTT-150.

The influence of the collision rates improvement on methanol lines estimates of the physical parameters of massive star formation regions.

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We compared the estimates of physical parameters of molecular cores by quasi-thermal methanol lines data. Estimates were obtained by two models of rates of collision excitation: Pottage, Flower & Davis (2001 – 2004) and Rabli & Flower (2010, 2 papers). Para-H_2 and He were regarded as collision agents of methanol excitation. The particle fraction of He was 0.2.

We showed that the differences between collision rates in the models do not have significant influence on the approximation quality of quasi-thermal lines intensities and final estimates of physical parameters. However, we find the Rabli & Flower (2010) model to be more preferably because it was intended for a greater number of levels (up to $J = 15$, including torsionally excited levels $v_t = 2$).

Using improved collision rates model for estimations of the physical parameters in the NGC 6334I

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The physical parameters of molecular core NGC 6334I were estimated by quasi-thermal methanol lines. Physical parameters such as hydrogen number density $n_{\mathrm{H_2}}$, temperature T_k, methanol fractional abundance and methanol column density were estimated with improved model of collision rates of Rabli & Flower (2010, 2 papers).

Because of the complex structure of the object, physical parameters were estimated by two groups of transitions: low excited ($v_t = 0,\ E_{\mathrm{up}} < 175\ \mathrm{cm}^{-1}$) and highly excited ($v_t = 1,\ E_{\mathrm{up}} > 415\ \mathrm{cm}^{-1}$) transitions. We concluded that the emission in the low excited transitions is generated in the region with physical parameters $T_k = (90 \div 115)$ K, $n_{\mathrm{H_2}} < 3.2 \cdot 10^5\ \mathrm{cm}^{-1}$; for highly excited transitions $T_k > 150$ K and, for $n_{\mathrm{H_2}}$, the 1σ confidence interval goes from 10^3 to 10^9.

Study of cold spots on the surface of the stars on to the Kepler space telescope data

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On the photometric observations with the Kepler space telescope the properties of the active regions (cold spots) on the surface of 737 stars with planetary systems (exoplanets) are studied. We consider the dependence of the degree of spottiness of stars with planetary systems on their effective temperature and the period of their rotation. There is no indication that the magnetic activity of stars with exoplanets has pronounced features that distinguish them from the activity of stars in the more extended sample. Spottiness of stars with planetary systems in the most cases does not exceed 5% of its surface., Three objects for which it exceeds the 5% are considered in detail. The behavior of spottiness parameter in a dependence on the rotation period of the star is considered.

We analyze the properties of the active regions (cold spots) on the surface of 279 stars of spectral type G, for which more than a thousand superflares with energies in the range of $10^{33} \div 10^{36}$ erg was discovered. The diagrams connecting the superflares energies with star activity index (area of their magnetic spots) are investigated. The extensive research of the activity of the two stars with a record value of flures was made.

Spectral properties of NS X-ray binary 4U1705-44 with BeppoSAX and RXTE. Quasi-constancy of the spectral index vs accretion rate

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We present an analysis of the X-ray spectral properties observed from the atoll-source 4U1705-44 during evolutions between island and banana states. We analyze observations using the RXTE and BeppoSAX. We find that the X-ray broad-band energy spectra during all spectral states can be adequately reproduced by a model, consisting a low-temperature Blackbody component, two Comptonized components arising from the seed photons coming from NS atmosphere at a temperature $kT_{s1} \approx 1.5$ keV (herein Comptb1) and a second resulting from the seed photons of $T_{s2} = 1.1 \div 1.3$ keV coming from the disk (herein Comptb2). We also include an iron-line (Gaussian) component in the spectra. The data analysis using this model indicates that the photon power-law index Γ_1 of our model is almost constant ($\Gamma_1 \approx 2$) for all spectral states. Another parameter, Γ_2 demonstrates a two-phase behavior depending on the spectral state. Γ_2 is quasi-constant at $\Gamma_2 \approx 2$ when the electron temperature $kT_e^{(2)} < 80$ keV and Γ_2 is less than 2, namely in the range of $1.3 < \Gamma_2 < 2$, when $kT_e^{(2)} > 80$ keV. We also detect a decrease of kT_{s2} from 1.3 keV to 1.1 keV during this high electron temperature phase. This phase is similar to that was previously found in the Z-source Sco X-1. We interpret the decreasing index phase using a model in which a high radiation pressure from the NS causes an expansion of the Compton cloud similar to that found previously in Sco X-1 during the Flaring branch.

Behavior of perturbations in an accretion flow on to a black hole

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We investigate the behavior of small acoustic perturbations in the spherical adiabatic relativistic accretion flow on to a non-rotating black hole. The Das model of the accretion [1,2] is a general relativistic generalization of the classical spherical Bondi accretion. We consider a general relativistic linear wave equation for small acoustic perturbations and fulfill the mode analysis of solutions. We find numerically that perturbations remain finite in amplitude on the event horizon due to the effects of the general relativity in contrast to predictions of the non-relativistic model based on the Bondi accretion approximation [3]. This circumstance downranges the possibilities for detection of black holes.

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Interstellar polarization and star formation studies in dark clouds

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It is well known that light from celestial sources as it passes through the interstellar medium gets polarized due to the aligned dichroic interstellar dust grains. However, at times the light passes through denser part of the interstellar medium containing diffused nebulae or interstellar clouds. Some of these clouds are undergoing gravitational collapse and may form stars. The amount of polarization caused by such intervening clouds provides valuable information and act as a good diagnostic to understand various processes associated with star formation.

The dichroic dusts present in such clouds generally get aligned by various mechanisms, among which magnetic field is an important one. The same magnetic field also plays a key role in star formation of dynamics and also helps in deciding the shape of the clouds. Some of these clouds have rotations, which together with magnetic field sometimes impede the gravitational collapse. The grains on the other hand absorb radiations at shorter wavelengths and re-radiate in infrared, helping energy balance mechanism. The thermally re-radiated emission also shows polarization.

With this background, many dense interstellar clouds were astronomically observed and studied by us in polarimetry, to understand the star formation processes in them. These results will be discussed.

Estimates of brightness temperatures and angular sizes for a number of maser sources observed by "RadioAstron"

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Maser sources represent one of the main targets of the RadioAstron science program. The ultra-high angular and high spectral resolutions of RadioAstron provide tight limits on the sizes of the most compact maser spots and estimates of their brightness temperatures. Current results of the maser survey data obtained in the RadioAstron observations are presented. Brightness temperature and angular size estimates for a number of maser sources are discussed. In star-forming regions very compact features with angular sizes from 45 to 60 angular micro-arc seconds have been detected. Corresponding linear sizes are about $(5 \div 10) \cdot 10^6$ km. Estimates of the brightness temperatures provide the values higher than 10^{14} to 10^{16} K.

Age and chemical composition of the nuclei of two unusual dwarf spheroidal galaxies

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KKs3 is one of a few truly isolated dwarf spheroidal galaxies within 10 Mpc. ESO269–66 is a close neighbor of the giant S0 Centaurus A. Each of the galaxies contains a massive globular cluster near its optical center. We estimate ages and chemical compositions of the clusters using their medium-resolution spectra obtained with the Southern Africal Large Telescope (SALT). The two nuclei appear to be very similar in their properties. We discuss our results in the context of theoretical studies in the field of globular cluster formation.

Metal ejection by galaxies and clusters of galaxies

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Chemical enrichment of the Universe stars from stellar activity in galaxies and extends further through the intergalactic medium. Recently extended (up to 100 – 200 kpc) circumgalactic halos with rather high metallicity (up to 0.1 solar) are discovered around many galaxies indicating that galaxies are far from being closed systems and instead are involved into a very powerful mass exchange with the intergalactic medium. Clusters of galaxies can be also a very important source of metals in the Universe. It is well known that the intracluster gas contains a considerable fraction of metals — its metallicity reaches 0.3 the solar metallicity. This can mean that even a relatively weak leakage of gas from clusters might be a very important source of metal circulation in the Universe. We present here simple estimates of this effect and its possible observational manifestations.

The complex astrophysical systems analysis with use of the stellar atmospheres method

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Results of close binary and stellar cluster investigations were presented. Formation of the stellar atmospheres with X-ray and UV irradiation was studied. The program SPECTR was constructed for modeling of optical radiation of close binaries with tidal components, reflection effects and deviations from LTE. More than 30 close binaries of different types (precataclysmic binaries, cataclysmic variables, massive X-ray binary, double degenerated, etc.) were investigated with definition their characteristics. Technique of reflection effects using for the analysis of structure and physical conditions in close binaries was developed. Chemical composition anomalies in systems with relativistic objects were studied. The program CLUSTER was constructed for modeling of stellar cluster integrated spectra. The technique of their fundamental parameters and a chemical composition determination was developed. The analysis more than 10 galactic and extragalactic cluster was made.

Correlation of radial fluctuations in deep galaxy redshift surveys

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Correlation analysis for photometric galaxy redshift catalog ALHAMBRA [1] was performed. Fluctuations of the number of galaxies within different catalogs were compared using the method of estimation of sizes and amplitudes of radial fluctuations for different redshift bins [2]. The compared catalogs are COSMOS [3], UltraVISTA [4], 10k zCOSMOS [5], XMM-COSMOS [6] and HDF-N [7]. The Pearson correlation coefficient of fluctuations between these samples has the value $R = 0.69 \pm 0.16$ for redshift interval $0.1 < z < 1.7$. This correlation observed between independent surveys of different research groups confirms the existence of super-large galaxy structures with sizes up to 1000 Mpc/h.

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Radiative transfer and spectra in stochastic atmospheres

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Various cosmic objects — stars, active galactic nuclei, accretion discs etc., are subjected to stochastic variations of temperature, large scale gas motions, magnetic fields, concentration of atoms and molecules. Stochastic variations of these values give rise to changes in absorption coefficients, Doppler widths etc. The existence of many reasons of fluctuations α' give rise to Gaussian probability distribution — $p(\alpha') \propto e^{-\alpha'^2 \cdot \mathrm{const}}$. Observed spectra are determined by values averaged over time of observation and observed surface. Usual model explanations of these spectra do not take into account the influence of fluctuations. In a number of cases these models do not explain satisfactory the observed spectra. In these cases the taking into account of fluctuations allows to improve the coincidence the theoretical spectra with observed ones.

A non-LTE line formation for neutral and singly-ionised titanium in model atmospheres of the reference A–K stars

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A comprehensive model atom of Ti I – Ti II was constructed using predicted high-excitation levels and accurate photoionisation cross-sections for the first time. It was tested with well-studied B – K stars of different luminosity ($\log g$) and metallicity ($-4 < [\mathrm{Fe/H}] < 0.5$). Consistent NLTE abundances from lines of Ti I and Ti II were found for the main sequence B – F stars, while in LTE the abundance difference Ti I – Ti II $\simeq 0.2$ dex. One of the main uncertainties in NLTE results for cool stars is the effectiveness of inelastic collisions with hydrogen atoms (S_{H}). We show that the Ti I/Ti II ionisation equilibrium is achieved within 0.06 dex for each of 15 F – G dwarfs in the $-2.7 < [\mathrm{Fe/H}] < 0.3$ metallicity range, when applying $S_{\mathrm{H}} = 0.5$ in the statistical equilibrium calculations. For seven turn-off (TO) and subgiant (SG) stars with $[\mathrm{Fe/H}] < -2$, the deviations from LTE are significant for both Ti I and Ti II lines and NLTE leads to discrepancy in abundances between Ti I and Ti II lines. This can be due to inaccurate treatment of collisions with hydrogen atoms in very metal-poor atmospheres. Accurate collisional data for Ti I and Ti II would be extremely helpful. We calculated the NLTE corrections for lines of Ti I and Ti II in the grid of model atmospheres with 4000 K $< T_{\mathrm{eff}} <$ 5000 K, $0.5 < \log g < 2.5$, $-4 < [\mathrm{Fe/H}] < 0$. They were applied to check atmospheric parameters and determine Ti abundances of stars in Sculptor and Bootes dwarf galaxies.

Determining the relationship between the components of the interstellar medium in H II complexes

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The star formation (SF) plays a key role in the evolution of galaxies. The efficiency of SF depends on the relative content of various components of the interstellar medium (ISM), in particular, on the content of molecular hydrogen, atomic hydrogen, and dust. However, there are still many uncertain ties in determining the content of gas and dust in SF complexes. In this work we present a study of various components of the interstellar medium (ISM) in HII complexes using observational data in the infrared (Spitzer Space Telescope and Herschel) and radio bands (IRAM and VLA) for eleven galaxies (Holmberg II, IC 2574, DDO 154, NGC 0628, NGC 2976, NGC 3351, NGC 3627, NGC 4736, NGC 5055, NGC 6946, NGC 0925) included in THINGS, KINGFISH, SINGS and HERACLES surveys.

Using data downloaded from the survey archives, we performed an aperture photometry of H II complexes. For some of the objects we evaluated a number of parameters, using Drain and Li (2007) model: the fraction of PAH mass in the total dust mass, the average intensity of the radiation field in an H II complex, the fraction of dust located in PDR, masses of molecular and atomic hydrogen. Metallicity for each region is also estimated. We present correlations between various dust parameters and correlations between dust and gas parameters. It is shown that:

1) Emission at 24 micron is correlated with long-wave length emission of dust;

2) Emission at 8 micron is correlated with CO emission;

3) Comparison of CO emission and dust 8 micron emission hints at a more effective destruction of CO and PAH in regions with low dust content(low metallicity).

Sun-sized masers in Cepheus A

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Using a space-to-Earth radio interferometer, the smallest ever angular structure has been discovered in an astrophysical maser, in the star-forming region Cepheus A, which has a linear size similar to the Sun's diameter. Difference in velocities of the maser features correspond to velocity gradient which is greater than previously observed in interstellar medium by more than an order of magnitude. Possible interpretation of these observations is discussed.

RM-synthesis: problems and perspectives

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RM-synthesis is a new method of interpretation for multiwavelength data of observations of polarized radioemission. We discuss possible applications of the method and problems arising on this way.

Stellar prominences to describe cyclical line profile variability of the O6 supergiant λ Cephei

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Many O and B stars show unexplained cyclical variability in their winds, i.e. modulation of absorption or emission features on the rotational timescale, but not strictly periodic over longer timescales. For these stars no dipolar magnetic fields have been detected, with upper limits below 300 G. Similar cyclical variability is also found in many optical lines, which are formed at the base of the wind. We propose that these cyclical variations are caused by the presence of multiple, transient, short-lived, corotating magnetic loops, which we call "stellar prominences". We present a simplified model representing these prominences as corotating spherical blobs to explain the cyclical optical wind-line variability in the O supergiant λ Cephei. From model fits we find that to represent the data we need 2 – 6 prominences with the lifetime between $1^h.2$ and $25^h.1$. Although the fits results may not be unique at this stage, the model constrains the inclination angle and the rotation period of the star. Similar behavior is observed in at least 4 other O stars. We propose that prominences are a common phenomenon among O stars. Other supporting evidence for such prominences comes from the recent discovery of photometric variability in a comparable O star ξ Per, which was explained by the presence of multiple transient bright spots, presumably of magnetic origin as well.

Spectral distortion of CMB and new results of the satellite "Planck", ground telescope at the South Pole and Cosmological Telescope in the Atacama desert

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The observations of the CMB led to the discovery of a thousand previously unknown massive clusters of galaxies at redshifts up to 1.75 from the analysis of effects associated with scattering of CMB photons by hot electrons in these extremely interesting objects. These data, together with the study of the noise spectrum in the maps of the comptonization parameter y in the sky over the received satellite "Planck", allow you to define the lower and upper limits of the fluctuating part of the parameter y over the sky. The resulting upper limit is 7 better than obtained with the remarkable COBE/FIRAS instrument 25 years ago. This result is important for cosmology, since it takes into account the contribution of the hot gas in galaxy groups, halos of massive galaxies and intergalactic shock waves associated with the growth of large-scale structure of the universe and the problem of uncounted baryons in the warm gas. In a similar way the upper limit of the fluctuating component of the chemical potential associated with the Bose-Einstein distortions of the CMB spectrum was found. At the same time the result of the COBE/FIRAS instrument was 15 times improved.

Satellite PIXIE (NASA) project promises increasing the sensitivity to the spectral distortion of the CMB in 1000 times in comparison with the COBE/FIRAS. Realization of this project and plans of development of detectors for ground submillimeter instruments will provide interesting constraints on the spectrum of primordial density perturbations of matter at small scales, completely erased due Silk's decay; on the parameters of unstable particles of dark matter, primordial black holes, magnetic fields, etc. and etc; opens a new window of information about the processes in the early universe and allow to observed spectral radio-lines from the era of hydrogen recombination and two helium recombinations in the universe.

Non-LTE models of the emitting regions in hot young stars

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The intermediate-mass young stars (so-called the Herbig Ae/Be stars) possess with a very complex environment consisted of accreting and outflowing matter. To determine a geometrical structure and physical properties of this environment we reproduce the spectroscopic and interferometric observables such as hydrogen line profiles as well as visibilities, differential and closure phases. For non-LTE modeling the emission in the hydrogen lines we use the Sobolev approximation. Fitting of the spectroscopic and interferometric observables permits us to constrain the model parameters and find main contributors into the line emission between such components as a magnetosphere, disk wind and accretion disk.

Orbital parameters and variability of the emission spectrum massive double system 105 Tau

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High resolution spectroscopy of the massive double system with the B3e primary 105 Tau were carried out in the spectral regions centered on H_α and He I 6678 lines. It is found faint lines of the secondary star that is less massive late B star. Physical parameters of orbit and possible masses of the components were found. Analyses of the orbital variability of the faint emission component in H_α let us conclude that mass loss come from the primary component on the less massive secondary and evolution status of the primary star is giant in the end of main sequence.

The relative content of the Be stars in the young open clusters

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The analysis of the population of B and Be stars in the young open clusters based medium resolution spectroscopy was carried out. It is found clear dependence of the relative content of the Be stars of early spectral classes (B0 – B3) from the age of the clusters. Relative concentration of the Be stars spectral B0 – B3 is increasing with increasing of the age, and reach the maximum value of 46% in the clusters with the age of $12 \div 20$ Myr. The almost complete absence of Be stars in more old clusters is easy explained by the leaving B stars at the main sequence. A few emission objects in the clusters with the age of $1 \div 7$ Myr are most probably the Herbig Be stars. Such distribution of Be stars in clusters, clearly points to the evolutionary status of Be-phenomenon. Probably reason that lead to such distribution of Be stars is wide spread (up to 75%) duplicity of the massive stars and mass and angular momentum exchange of the close binaries. Numerous examples of such double system in the young open clusters were found during our observations.

The fluctuations of emmission intensity of PSR J0653+8051 at 111 MHz

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We present investigation of PSR J0653+8051 at 111 MHz frequency made by Large Phase Array (Pushchino, Russia). This pulsar shows three componentsin $102 \div 4850$ MHz range. We detected a few dozen very strong pulses above the mean profile amplitude for more than 110 times. Usually this pulsar demonstrates very weak signal at mean profile's 3σ level. Detailed analysis showed that all strong pulses with $(5 \div 20)\,\sigma$ signal-to-noise ratio arrived only on the central component longitude. This effect is uncommon because we detected such giant components just in two days among around four hundred days of observations.

X-ray spectral index correlations vs mass accretion rate in neutron star and black hole X-ray binaries in their different spectral states. Theory vs observations

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We present details of observations of neutron star (NS) and black hole (BH) binaries and the first principle theory of X-ray spectral formation in neutron star (NS) and black hole (BH) binaries. We show our model predicts the spectral index correlation vs mass accretion rate as in the case of NS as well in the BH case. In BHs the spectral index should increase and then saturate with mass accretion rate because the index as an inverse of Comptonization parameter Y and Y-parameter saturates with the high mass accretion in the converging flow onto BH. Comparison of this model prediction with X-ray observations shows that in BH case the index, indeed, correlates and then saturates with mass accretion rate. Moreover this index-mass accretion rate correlation allows us to estimate BH masses and distance to the source. While in NS sources the observations shows that the index stays the same independently of spectral state of the source which can be possible if the energy release in the disk is always much smaller of that at NS TL (boundary layer).

Energy budget in multiple supernova explosions

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Standard models of large scale galactic outflows in starburst galaxies assume a high efficiency of SNe in heating the gas in central regions of starburst galaxy in order to launch outflows. We study the heating efficiency of the interstellar gas by multiple SNe within 3D simulations. We argue that SNe remnants have to act coherently in space and in timein order to minimaze radiative losses. We show that interacting expanding shells from different SNe restrict the heating efficiency of multiple SNe even when they explode with high rate. As a result the heating efficiency can considerably differ from a commonly assumed value $(0.1 \div 0.3)$.

Metal ions in circumgalactic medium

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Recent observations show high column densities of metal ions in extended haloes of galaxies within $z \sim 0 \div 3$. For instance, to explain column densities of O VI ion observed around starforming galaxies one should assume solar metallicity in the extendend haloes, and in this case the haloes become the main reservoir of missing baryons and metals. Using time-dependent radiation field of a nearby starburst galaxy we study the evolution of ionic species depending on the galactic mass and star formation rate. We derive conditions for the high ionic states of metals to appear in extended galactic haloes.

Anomalies of low multipoles of WMAP and Planck missions

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We consider the main anomalies of the cosmic microwave background (CMB) observed at low multipoles of the WMAP and Planck cosmic missions. They are the hemisphere power asymmetry, the Axis of Evil, the Cold Spot and some others. The anomalies are the observational signatures of the statistical anisotropy of the registrated CMB signal. The possible origin of these features is discussed. Some features are slightly different on the WMAP and Planck maps. We study difference between WMAP and Planck data which is apparently connected with the local sources emission and/or systematic.

Faint radio galaxies on the Planck mission maps

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We have cross-identified radio galaxies from different populations with the Planck mission maps. Subsamples of radio sources includes RATAN-600 RCR-objects, giant radio galaxies and steep spectrum radio sources from other radio telescope surveys. We detected the positive microwave signal of faint radio sources both on the Planck channel maps and on the CMB maps. We used the single area source detection and the stacking procedures for sources of the same population. Some zones of the multi-frequency Planck maps around radio galaxies demonstrate the Sunyaev-Zeldovich effect signatures which are not cataloged in the published SZ-object lists.

On the complex Milne problem

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In some problems of radiative transfer one has to use the photon path-length distribution function. If we try to find it by exploiting the van de Hulst equivalence theorem then one of the possible ways is to use the inverse Laplace transformation. Since the function to be transformed is not simple we have to apply some numerical method. One of the most suited is the Piessens-Huysmans method. But this method, being quite accurate, takes us to the range of negative or even complex albedos of single scattering.

It appeared that the non-linear integral equations for the complex H-function and the H-matrix are valid even in the complex plane. This problem has been considered in author's earlier works. In this report we have generalized the approach to the whole complex radiation field in the case of the Milne problem by using the approximation of the Sobolev resolvent function as a series of exponents. This treatment allows us to express all the relevant functions of transfer by simply findable auxiliary functions.

X-ray observations of galaxy clusters: cosmology and physics of the hot intracluster gas

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Clusters of galaxies are unique cosmological probes and sites where the physics of the hot intergalactic gas is conveniently exposed. I will review detailed X-rays observations of the hot gas in clusters obtained with the Chandra X-ray Observatory on a wide range of scales, from the central region affected by the supermassive black holes in the central galaxies to the edge of the cluster near accretion shock. I will discuss prospects of using cluster data for cosmological constraints (e.g., mass of light neutrinos). Studies of galaxy clusters will be brought to the next level with the future-gerenation X-ray telescopes. I will give a summary of the current activities in the US.

Optical spectroscopy of ultra-luminous X-ray sources with BTA

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We present the results of optical spectroscopy with the 6-m Russian telescope BTA of Ultra-luminous X-ray sources (ULXs), photometry with Hubble Space Telescope and spectral energy distributions in the X-ray range. We have identified optical counterparts of ULXs in the galaxies NGC 5474 and M 66. We obtained optical spectra of the transient ULXs in UGC 6456, NGC 5474 X-1, and the persistent source in NGC 4395. We have detected broad emission lines H_α and He II 4686 in the optical spectra of the ULX counterparts.

The study of inelastic processes in collisions of beryllium and hydrogen

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Atomic and molecular data on the processes occurring in low-energy collisions with hydrogen is very important for astrophysical modeling of stellar atmospheres. Accurate quantum calculations are time-consuming and difficult, so it is important to develop and apply reliable model approaches such as described in [1,2]. This approach in the framework of Born-Oppenheimer formalism is based on asymptotic method and multichannel Landau-Zener model, and was applied to low-energy inelastic collisions of silicon and aluminum atoms and positive ions with hydrogen atoms and negative ions [2,3].

In the present study the model approach is applied to inelastic low-energy beryllium-hydrogen collisions. This research includes 12 low-lying covalent states and one ionic. Cross sections and rate coefficients for excitation, de-excitation, mutual neutralization and ion-pair formation processes are calculated. It is shown that the processes with the largest values of cross sections and rate coefficients involve non-adiabatic transitions to Be(3p)+H and Be(3d)+H states.

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Interstellar polarization: from UV to submm

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Interstellar (IS) polarization was discovered in 1949 in the course of the search for the Sobolev-Chandrasekhar effect. This polarization is caused by the linear dichroism of the IS medium arisen due to the presence of non-spherical aligned grains. Dust grains must have sizes close to the wavelength of incident radiation and specific magnetic properties to efficiently interact with the IS magnetic field. Modern investigations of IS polarization are focused on the probe of the structure of galactic magnetic field using distribution of polarization vectors and study of the wavelength dependence of polarization. A special attention is paid to the dust polarized emission observed in far-IR and submm part of spectrum and especially measured by Planck.

Using spheroidal grains with imperfect alignment [1–3], we model the observational wavelength dependence of polarization and the polarizing efficiency of the IS medium in different directions. We show which factors are the most important for estimates of the dust properties and the geometry of magnetic field.

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Infrared emission of galactic and extragalactic star-forming regions

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Dust is one of the major constituents of the interstellar medium, and its emission is one of the most informative tracers of the star formation process. But the interpretation of observational data on the dust emission is hampered by both the dust evolution and the complexity of the radiation generation and transfer properties. Results on the modelling of the dust component evolution and dust radiation transfer in galactic and extragalactic H II regions and star-forming region will be outlined in the talk. The following conclusions will be presented:

1) Morphology of the near infrared emission maps in galactic H II regions indicates that the smallest dust particles (PAHs) are most probably destroyed in the vicinity of ionizing stars.

2) Further away from the star relative abundance of the smallest grains can both decrease due to their destruction and increase due to destruction of bigger grains.

3) The source of the emission in the Spitzer 24 micron band is still unclear and can be related to both stochastically heated very small grains and hot bigger grains.

Transport properties of nuclear pasta in neutron stars

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Neutron stars may contain a layer of nuclear pasta where atomic nuclei form exotic nuclear clusters of funny shapes (which resemble lasagna, spaghetti, Swiss cheese, and other tasty things). If appears, the pasta layer is situated between the ordinary neutron star crust and the liquid superdense core. The layer is thin but contains a sizable fraction of the crust' mass. The nature of the nuclear pasta layer is outlined and its main physical properties are described, including thermodynamics, kinetics, and neutrino emission. An emphasis is made on electron transport through nuclear pasta with strong magnetic fields. This transport is anisotropic and gyrotropic, much richer in physics than the electron transport through ordinary neutron star crust of spherical atomic nuclei. The tensor structure of electron thermal and electric conductivity and electric resistivity is described, and the dependence of tensor components on the magnetic field is studied. It is shown that the nuclear pasta layer is a special place in a neutron star where transport and other properties are remarkably different from those in other layers. Possible effects of the pasta layer on observational manifestations of neutron stars are discussed including thermal, magnetic and rotational evolution of neutron stars. The main problems for future studies of nuclear pasta are formulated.

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Model approach for inelastic processes in collisions of heavy-particles with hydrogen

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Information on inelastic collision processes is important for non-LTE modeling of stellar atmospheres. One of the main sources of uncertainties here are collisions with hydrogen. A full quantum treatment of these processes is very laborious and for many atoms of interest the required data is unavailable. That's why to estimate inelastic collision rate coefficients Drawin formula is still used although it has been shown [1] that it doesn't provide a reliable data and can't be applied to charge transfer processes, which have been found to be the most important in astrophysical applications.

The model approach in the framework of Born-Oppenheimer formalism has been recently proposed [2] to evaluate physically reliable data for inelastic collision processes. Proposed electronic structure modeling allows to describe long-range nonadiabatic regions due to ionic-covalent interaction and obtain adiabatic potentials for high-lying excited states that can also be combined with available ab initio data for low-lying states. Nonadiabatic transition probabilities between adjacent molecular states are calculated using the Landau-Zener model. When nonadiabatic regions are passed in a particular order the multichannel formula can be used to calculate the total transition probability [3]. When adjacent states form several nonadiabatic regions the branching probability current method should be applied [2].

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Galaxies at different stages of interaction

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We present the results of the spectral study of three peculiar galaxies (candidates to polar ring galaxies). New information about structure and kinematics of gaseous and stellar components was obtained using modern observing techniques such as integral field (3D) spectroscopy and high resolution long-slit spectroscopy (at the Russian 6m telescope). UGC 8387 is on the stage of merging of two galaxies. We suppose that the brightening at a distance of $9''$ to the SE direction from the nucleus represents a separate system like a dwarf Im galaxy which can be a remnant of a companion galaxy. The structure along the minor axis of the main body is the ionized gas and stars pulled off from the companion galaxy. The SE tail is possibly a tidal spiral arm of the galaxy. NGC 3310 is on the stage of relaxation. In its central region ($r < 10''$) non-circular motions take place. There the change of dynamical axis position angle and inclination with distance from the center is observed; this can indicate the presence of the warped inner disk/ring. The outer part of the galaxy ($20'' < r < 70''$) can be approximated by the model of a circular rotating thin disk. The NE tail-like structure most likely lies above the plane of the main body disk. UGC 1198 has already formed inner polar ring. Our research revealed that the main body of the galaxy is poor of gas, and the ionized gas belongs to the peculiar structure, which is possibly disk. The ionized gas of this disk rotates around the major axis of the galaxy.

O_2 dayglow atmospheric emissions as tracers for variations of atmospheric composition in the mesosphere and low thermosphere

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Advanced model YM2011 for emissions of electronically-vibrationally excited products of O_3 and O_2 photodissociation was developed by us at the atmospheric physics department of Saint-Petersburg State University in 2003 – 2011 (Yankovsky, Manuilova, 2006; Yankovsky et al., 2011). As a whole, more than 150 aeronomical reactions of photoexcitation and deexcitation, including the energy transfer between excited states and the quenching of states in collisions with $O(^3P)$, O_2, N_2, O_3 and CO_2 are considered. Upon absorption of solar irradiance (spectral range $120 \div 320$ nm) by O_2 and O_3 molecules the electronically-vibrationally excited photolysis products O_2 ($b^1\Sigma_g^+,\ v \leqslant 2$) and O_2 ($a^1\Delta_g,\ v \leqslant 5$) are generated. The system of kinetic equations for these excited components has been solved and altitude profiles of the Volume Emission Rates of Atmospheric bands O_2 ($b^1\Sigma_g^+,\ v' \leqslant 2 \to X^3\Sigma_g^-,\ v'' \leqslant 2$) (in spectral range $629 \div 997$ nm), IR Atmospheric band O_2 ($a^1\Delta_g,\ v = 0 \to X^3\Sigma_g^-,\ v'' = 0$) and Red line of $O(^1D)$ have been calculated in the interval $40 \div 140$ km for different solar spectra, atmospheric compositions and solar zenith angles, based on data of TIMED-SABER satellite.

The aim of this study is revealing of tracers for retrievals of atomic oxygen and ozone. To compare characteristics of assumed proxies we used sensitivity analysis of the tracer emission intensities to variations of $[O(^3P)]$ and $[O^3]$ concentrations We took into account five characteristics:

1) altitude range, available for $[O(^3P)]$ remote sensing;
2) clearness of photochemical kinetics mechanism;
3) volume emission rates of these excited components;
4) photochemical lifetimes of excited states;
5) relative uncertainties values of $[O(^3P)]$ retrieved from intensities of emissions formed by the corresponding radiative transitions.

Based on this comprehensive analysis we concluded that the optimal proxies for $[O(^3P)]$ retrieval are emissions of O_2 ($b^1\Sigma_g^+,\ v = 2$) and/or O_2 ($b^1\Sigma_g^+,\ v = 0$) nearly altitude $90 \div 140$ km, and also emissions of O_2 ($b^1\Sigma_g^+,\ v = 1$) and O_2 ($a^1\Delta_g,\ v = 0$) about $40 \div 95$ km for $[O_3]$ retrieval.

Simulating the Universes epoch of reionization

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The Epoch of Reionization is one of the least explored epochs in the history of the Universe. The redshifted 21 cm line from neutral hydrogen emitted during this epoch is the most promising probe for exploring it. To date there are a number of low frequency radio telescope that are aiming at detecting this radiation (LOFAR, MWA, PAPER, SKA, etc.). Here I present a fast Cosmological Radiative transfer simulations, calls BEARS, and what do we learn from it on the Epoch of Reionization physics and astrophysics.