

Dark Matter in the Solar System

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Abstract: Some mechanisms of dark matter density enhancement in the Solar system are considered. Also, the unexplained phenomena within Solar system (the Pioneer anomaly and the flyby anomaly) are discussed.

The unperturbated density of dark matter (DM) in the vicinity of the Sun is 0.3 GeV/cm^3 . A typical velocity of dark matter particle is about 300 km/s with Maxwellian velocity distribution. There are several processes able to increase the density of DM in the Solar system:

1. gravitation-collisional capture
2. gravitational capture
3. particles focusing in the Solar system gravitational field
4. baryon compression

Gravitation-collisional capture:

The dark matter particles collide with the Solar system bodies losing their energies and settling bound orbits. The dark matter halo properties depend essentially on mass and cross sections of DM particles. For example, for the DM particle with electric or magnetic charge, the halo around the Sun will be formed for the particle mass $\sim 10^{16} \text{ GeV}$. The halo has a size of a few solar radius and the amplification factor is approximately a few units.

Gravitational capture:

This mechanism can be realized only in many particle collisions and does not depend on nongravitational interaction of DM particles. The most important example in the Solar system is interaction of a DM particle with the Sun-Jupiter system. This mechanism forms a new population of DM particles with distribution size of order of Jupiter orbit.

Particles focusing in the Solar system gravitational field:

This effect is connected with the uncollisional focusing of particles in an arbitrary gravitational field. It may form caustics near gravitating bodies of the Solar system. A characteristic size of the forming halo near the Sun is the Solar radius. The amplification factor for the Earth orbit connected with the winter-summer effect is $\sim 10 \%$. This mechanism forms the DM halo around any object, for example near the surface of neutron star the amplification factor is ~ 600 .

Baryon compression:

This mechanism describes the dark matter structure formation during the birth of the Solar system. It is analogous to the well known effect of baryon compression during the formation of the large scale structure of the Universe. This mechanism can be neglected..

In the present time there are some unexplained phenomena within the Solar system:

The Pioneer anomaly:

The anomalous unexplained acceleration of the Pioneer 10 and 11 spacecrafts:

$$a = (8.74 \pm 1.33) 10^{-10} \text{ m/s}^2$$

The Flyby anomaly:

The anomalous orbital energy changes observed during six spacecraft flybys of Earth.

This anomalies may be considered as a manifestation of an unknown population of gravitating bodies of the Solar system and a detailed analysis of all theoretically possible scenarios is necessary.