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Study on Kuiper Belt- Unexplored Reservoir of Solar System's Secrets

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Abstract:

Kuiper belt is a very vast elliptical plane which is home to our dwarf planet Pluto as well as Haumea which is considered as minor planet and is a trans-Neptunian object-its orbit is beyond that of the farthest ice giant in the solar system. Haumea takes 3.9 hours to make a full rotation and it has by far the fastest spin, and thus calculates to uphold the shortest day in our solar system for any planet or KBOs. Kuiper Belt is still a very mysterious place, and we have a lot to learn about it and through it, about our solar system.

Besides Haumea most Kuiper belt objects are too faint for meaningful compositional study but the objects discovered till date assumed to hold the capability to reveal the secret of generation of our solar system as the studies done till date suggests that the residues and all of the other leftovers after and whilst formation of solar system dived into the Kuiper Belt. Since the atmospheric condition in the belt id dynamically less the objects might be still in its earliest of form rather being degraded with the time.

Keywords: *Kuiper Belt, Solar System, Haumea, Comets.*

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Introduction

Kuiper Belt is vast expanse of space beyond the last known gas huge of the Solar System, the Neptune. The Kuiper Belt is as old as the Solar System. It was during the formation of our Solar System that utmost of rocks, dusts and gases were used up to form the Sun and the 8 planets. The remaining rocks, dusts and gases were then swept away into the Sun or the outer ranges of the Solar System. This space is composed of icy objects (Baidya, 2014).

Its Discovery-

In 1950, it was proposed by Jan Oort, a Dutch astronomer that the comets that we see in our recognized solar system actually originate from far spreads of the solar system. Before that, Kenneth Edgeworth, yet another astronomer, proposed in 1943 that large celestial objects and comets might exist beyond Neptune. Finally, astronomer Gerard Kuiper, in 1951 predicted the existence of a vast expanse of icy object beyond Neptune. This stretch is today known as Kuiper Belt. (Baidya, 2014)

Location of Kuiper Belt-

The Kuiper Belt extends from roughly the orbit of Neptune (at 30 AU out to about 55 astronomical units from the Sun. The main body of this belt covers much of this region, ranging from nearly 40 AU to 48 AU. It is thick in most places and astronomers have described it as being more torus-shaped than a belt would be. Other regions of the Kuiper Belt include a disk of scattered objects that are part of a population of worlds called Trans-Neptunian Objects.

Its Shape and Size-

Kuiper Belt is elliptical in plane. It spans over a distance of 4.5 to 7.4 billion kilometers from Sun. This is approximately 30 to 50 times the distance of Earth from Sun.

Kuiper Belt Object (KBO)-

The largest Kuiper Belt Objects are- our dwarf planet: innumerable comets, Pluto, Quaoar, Makemake, Haumea, Ixion, and Varuna. All of these are often referred to as Trans-Neptunian Objects (TNOs).

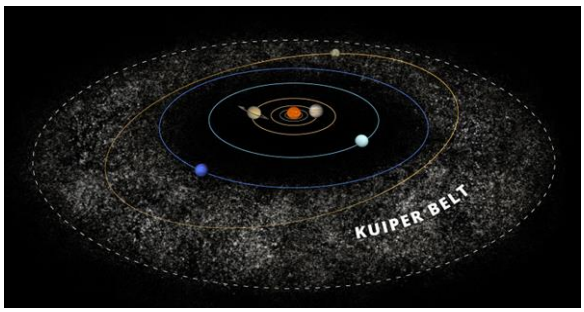

Figure no.1:Kuiper Belt in Solar System

Review of Literature

Malhotra, 1996 described in her article that the Solar system beyond Neptune is believed to reservoir of small primordial bodies which was left over from formation process of the planet. Her work describes the dynamics of small objects near the major orbital resonances with Neptune. She explained that near orbital resonance with Neptune, the phase resonance is more stable. Estimates of the widths of stable resonance zones as well as the properties of resonant orbits were obtained from the circular, planar restricted three-body model. Although her model didn't held the full intricacy of the long term orbital dynamics but somehow provides a baseline for the phase structure and assets of trans-Neptunian Solar system.

Stern and Colwell, 1997 studied that how does the Kuiper belt and its trans-Neptunian disk of comets and small planet-scale objects originated and evolved to its present mass and architecture. They used time-dependent model of collisional evolution of the EKB and based upon their findings they concluded that a wide range of assumptions, collisional evolution should have depleted the mass of the 30-50 AU zone by >90% early in the history of the solar system, thereby creating a deep scar or gap in the surface mass density across a wide region beyond Neptune and that Neptune has had far less dynamical influence beyond 50 AU. In the end it was further mentioned that unless the solar nebula was truncated near 50 AU, then surface mass density of solids somewhere beyond ~50 AU may increase again dramatically.

Gladman et al., 2001 in his paper has described structure of Kuiper belt in terms of size distribution and radial extent. The facts in the paper was included by studying Kuiper's apparent magnitude distribution via deep imaging on the Canada-France-Hawaii Telescope and the ESO Very Large Telescope UT1. The finding of the paper was that the entire range of

observed objects (magnitudes mR ~ 20–27) is well represented by an unbroken power law, with the number of objects per square degree brighter than magnitude R being of the form $\Sigma (mR < R) = 10$, with $\alpha = 0.69$ and $R0 = 23.5$. Also that there was steep size distribution in the observed range according to the luminosity function's slope. In the paper it was concluded that roll over is for diameters of less than 50 km, in agreement with collisional models and a belt mass between 30 and 50 AU of order 0.1 $M\oplus$, relatively insensitive to the roll over diameter as long as the latter is 1 km.

Brown, 2001 developed a general method for determining the unbiased inclination distribution of the Kuiper belt by using only the inclination and latitude of known Kuiper belt objects (KBOs). He used the data of all 379 known KBOs to determine the inclination distribution. They concluded their findings as that a natural analytic form for the inclination distribution is a sine of the inclination multiplied by a Gaussian. On the basis of which he reported that the inclination distribution of all KBOs is well fitted by sin I multiplied by a sum of two Gaussians with widths 2 6 and 15° ± 1°. For this inclination distribution, the Kuiper belt has an effective area of 8100 deg2 and a FWHM of 12.5° ± 3.5° in latitude. Further added that in every other scenario of angle, observance etc. the inclinations of the Kuiper belt objects appear larger than expected from dynamical simulations of possible unrests.

Trujillo and Brown, 2002 studied between the co-relation of Kuiper's belt color and inclination. The measured broadband optical BVR photometry of 24 classical and scattered Kuiper belt objects (KBOs) by doubling the published sample of colors for these classes of objects and reported a significant conclusion. In their work, they excluded excludes simple origins of color diversity like coloring agent or effects. They concluded through their data that spurious correlation induced by sampling bias, as perihelion and inclination are correlated in the samples of KBOs observed. But somehow they fail to establish the fact that whether the color and inclination trend is due to environmental factors, such as collisional resurfacing, or primordial population effects.

Levison and Morbidelli, 2003 mentioned Kuiper Belt as 'dynamically cold Kuiper belt'. Their work was majorly done on the formation of the belt through outward transport of the bodies especially during the phenomena of Neptune's migration through the belt. The reported that the belt consists of objects on low-inclination orbits between ~40 and ~50 AU from the Sun and currently contains material adding up less than a tenth the mass of the Earth. They concluded that the entire Kuiper belt formed closer to the Sun and was transported outward during the final stages of planet formation. And also, objects would not have grown to their present size unless the cold Kuiper belt originally contained tens of Earth masses of solids, although there are significant limitations in the observance mechanism of mass depletion.

Elliot et al., 2005 majorly worked on the study of core population of Kuiper Belt and its dynamical classification. There was search optimized with Blanco and Mayall 4 m telescopes at the Cerro Tololo Inter-American Observatory and Kitt Peak National Observatory their survey has a mean 50% sensitivity at VR magnitude 22.5. They reported discoveries of 320 labelled KBOs and Centaurs for the period 2000 March through 2003 December. They concluded that inclination distribution confirms the presence of "hot" and "cold" populations, the cold population shows a concentrated "core" with a full width at half-maximum of approximately 4 6, while the hot population appears as a "halo," extending beyond 30°. Also that, inferred latitude distribution is reasonably consistent with the latitude distribution derived from direct observation.

Conclusion

Solar system that stretches beyond Neptune is thought to be a reservoir of small primordial bodies. Kuiper belt is one of the oldest belt known in solar system which is located beyond Neptune (at 30 AU out to almost 55 astronomical unit). And came to light during 1950 that all the comets originate from this region which is full of icy objects. Astronomers like Oort and Kuiper strongly support this theory. Levison and Morbidelli believe and refer to it as dynamically cold belt, and have studied majorly the formation of this belt. Although many studies and observations have been made, yet universe remains a mystery that needs to unfold many hidden secrets, in order to explore this area many more discoveries are yet to be made.

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