body; rather it may represent a local hyperproliferative response to unknown angiogenic signals.

A report by Lo and Liotta[12] claiming that transfection of KS 'oncogene' into NIH-3T3 cells leads to the formation of murine KS-like neoplasms may also represent a growth-factor gene. Further characterization of this interesting phenomenon of DNA transfection leading to murine tumours of the same histopathological type as the human KS has not been forthcoming. Della Bovi and Basilico more thoroughly analysed[13] a transforming gene for NIH-3T3 cells derived from human KS and found that it is derived from sequences adjacent to the c-*fms* oncogene. The authors point out, however, that this gene may have been 'activated' during the preparation of the DNA, as there is no evidence of sequence rearrangement in the original KS DNA. Of course, if the KS cells are not clonal, it would be difficult to detect.

The epidemiology of KS remains something of an enigma. In AIDS it is seen in association with sexually transmitted HIV, less frequently among drug abusers, and is virtually unknown in haemophiliac AIDS. The incidence of KS is falling among homosexuals with AIDS. Although the primary aetiological agent for KS awaits discovery, the manipulation of KS cells in culture and xenograft with the growth factors developed by Gallo's group should help to delineate further properties of this fascinating tumour. □

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Solar System

Planetary planarity

David W. Hughes

THE Solar System is flat. But is this a relic of the origination process, the planets being formed out of a flat disk of accreting planetesimals orbiting in the equatorial plane of the cloud of gas and dust that surrounded the newborn Sun? Or did the system become flat later, this flatness being imposed by the gravitational dominance of Jupiter, the most massive planet? Also, does the flatness of the Solar System limit the size and the distance of nearest approach of the star which has passed closest to the Sun in the lifetime of the Solar System (4,570 million years)? These questions are investigated by Donald E. Morris and Thomas G. O'Neill in a recent issue of the *Astronomical Journal* (**96,** 1127–1135; 1988).

All planetary orbital parameters vary with time owing to their mutual gravitational interactions. By using a computer to trace the Solar System back 100 million years it has been found, for example, that the inclination of the orbit of Jupiter to the orbit of the Earth varies in a quasiperiodic fashion between 0.17° and 0.57°. In the case of Neptune, the most weakly bound of the planets, the range is 0.46°–0.86°. The variation in the orbital eccentricity of these planets is 0.025 – 0.062 and 0.0001 – 0.023, respectively. No secular trends have been found. These findings support the relic theory and indicate that Jupiter has done no more than influence the size of the range of variability.

The small mean inclination 0.69° and mean eccentricity 0.01 of Neptune could be accounted for in two ways. They could be relics of the formation process, but in addition we would have to conclude that they have not been affected by a star passing close to the Solar System since that formation. Or they might have initially been much larger and have subsequently been reduced by a passing star. Morris and O'Neill show that the latter of these two possibilities is most unlikely and indicate that passing stars cannot have changed the inclination and eccentricity of the planets by more than about the mean values that they have today. So the stellar-induced changes in the orbital velocity of Neptune and Uranus can have been no more than 0.084 and 0.3 km s^{-1}, respectively, during their lifetime.

The change in planetary velocity introduced by a passing star can be easily calculated and is a function of the star's velocity, mass, miss-distance and the encounter geometry. The change in the velocity occurs in a time that is much shorter than the planet's orbital period. Also a star that passes on a path parallel to the planet–Sun direction produces a much smaller perturbation than one that passes perpendicular to that line. By using the known stellar spatial density and velocity distribution in the solar vicinity, Morris and O'Neill calculate how close stars have to come to the Sun in the past and find that the inclinations and eccentricities of Saturn and Uranus, and the eccentricity of Jupiter, almost certainly have not changed significantly because of stellar encounters since the formation of the Solar System. Even for Neptune the probability of a stellar encounter capable of changing its inclination and eccentricity by more than half its present value is less than 3 per cent.

These limits indicate that no star with a mass greater than 0.1 solar masses has passed through the Solar System during the system's lifetime and no object with a mass more than three times that of Jupiter has passed within the orbit of Earth. Also no weakly bound object (such as a black dwarf star or a giant comet in a distant but eccentric orbit around the Sun) of mass greater than 0.01 solar masses has passed through the system. This, however, does not rule out the existence of a Nemesis-like solar companion as long as it always stays at great distances from the Sun. Remember also that the Sun was initially a member of an open cluster of stars. The Pleiades and Hyades are typical examples of such clusters. Some 10^8 years ago the Sun escaped from its parent cluster, and in its present position in the galactic disk the special density of stars (3.3×10^{-42} stars km^{-3}) is about one third its initial value. In the cluster, close stellar encounters would be three times more common.

There is one more signficant conclusion. Passing stars cannot be invoked to strip away outlying planets, especially the as yet unobserved Planet X that is a favourite of astronomers trying to explain apparent minor perturbations in the orbits of the outer planets. So the boundaries that the Solar System has today are the boundaries that it had initially. No big planets beyond Neptune have been lost.

Needless to say, I have been discussing stars getting *really* close to the planets. Significant numbers will have passed through the Oort cloud of comets, a cloud that occupies a spherical shell of inner radius 10,000 astronomical units (AU; 1 AU equals the mean radius of Earth's orbit) and outer radius 100,000 AU centred on the Sun (see for example Stern, S.A. & Shull, J.M. *Nature* **332,** 407–411, 1988).

I still, however, have one niggling worry. If the planetary planarity is primordial and the planets and the Sun were formed at the same time and from the same cloud of gas and dust, why does the planetary plane not coincide with the equatorial plane of the Sun, instead of being inclined to it by 7.25°? Maybe 7.25° is close enough to 0.0° to be negligible. But maybe not. □

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