EPSC Abstracts
Vol. 7 EPSC2012-228-2 2012
European Planetary Science Congress 2012

What process gave the solar and exoplanets their huge orbital a.m.? Multiple evidence in both arenas of its dynamical control during planetary construction, with a major bearing on the physics of gravitation

M.F. Osmaston
The White Cottage, Sendmarsh, Ripley, Woking, Surrey GU23 6JT, UK (miles@osmaston.demon.co.uk

Abstract

The present solar planetary system is replete with dynamical constraints on how it was built, and further constraint is provided by accumulating exoplanet observations. In this regard, the most fundamental, securely determined and far-reaching dynamical constraint of all - the high orbital angular momenta of the planets - has been recognized for nearly a century [1-5], but has proven to be the most elusive to explain within the currently prevailing variants of the Kant-Laplace paradigm. My purpose here is to underline the serious importance of this failure by working through the various planetary system features affected by it, and then to outline a possible way ahead.

The essence of the problem is that the mean specific orbital angular momentum (a.m.) of the solar planetary materials is ~$1.3x10^5$ times the rotational a.m. of solar material. Individual planetary a.m. arises from the prevailing Keplerian velocity pattern. Sparse exoplanet data on central-body rotation show no sign that the star's rotation is anywhere near fast enough to remove this huge disparity of a.m. So our approach to resolving this problem is to acknowledge that nebular action during planet formation was the only agent available for such 'partition' of a.m.

In practical terms this would likely involve both a slowing of the stellar spin and a growth in the orbital a.m. (i.e. orbit radius) but the latter (with no limit on orbit radius) could clearly become the major contributor. Such action, by whatever means, implies that planetary growth must be completed during the period of nebular presence, so that all their growth materials are equipped with the appropriate a.m.

The near-circular orbits of all except Mercury are indeed consistent with completion in the presence of nebular gas-drag. Further, to systematically increase orbit radius, the mode of planetary growth cannot be by the widely supposed growth by random impact. That is not the way systematically to increase its orbit size and a.m.

So where and how were the SS protoplanets nucleated and achieve their growth? This introduces the matter of planetary spin directions. Mercury's spin is probably irrelevant, having suffered a late giant impact (tilted and highly eccentric orbit, 2/3rds of its mantle missing) [6,7]. Of the 7 other planets all are prograde except Venus, whose very slow retrograde spin might be due to retrograde-capturing large amounts of the Mercury impact debris. We do not regard the 98deg inclination of Uranus as rendering it 'retrograde'. Restoring it by the full angle makes its satellite pattern like those of the other three Giant Planets. Moreover, Uranus' orbit is now the most circular of all, so the impact which tilted its axis must have been quite early, giving time for subsequent circularization by nebular action. So I conclude that we are looking for a nebula-present mode of planetary construction which leads to a systematically prograde spin result. Such systematic behaviour hints strongly at gravitational nucleation.

Note at once that in a Keplerian disc the vorticity is retrograde. The only place where prograde vorticity would be available in a plasma-rich protoplanetary disc is very close to the Sun and due to quasi-equatorial magnetic coupling. This point immediately strikes a chord with the exoplanet scene. There, ~23% of all those found have major-axis orbital distances of <12 solar radii. The proportion has changed little as the numbers grew, despite changes in detection methods. It is not a matter of ease of detection, but of why they are there at all, when Mercury, our closest-in planet, is at 83 solar

radii. Various people have sought to explain this as the result of **inward** migration due to gas drag, but that overlooks the problem of how they had the higher a.m. of being in a bigger orbit to start with.

Evidently, the SS planets must have derived their prograde spins from being nucleated - perhaps successively - in close-to-Sun positions, screened from it by nebular opacity, subsequently enlarging their orbits in the course of their growth in a.m. The close-in exoplanets that we can see are exposed to us and to their star by departure of the nebular agent that would have continued to push them outward, so may eventually vanish by evaporation. As did any inside Mercury?

The remaining dynamical question is how to preserve, during protoplanet growth and outward progress to its present orbital distance, the prograde spin each protoplanet acquired by close-in nucleation. The answer, affirmed by the systematically prograde orbits of the inner 56 satellites of the Giant Planets, is that those are the residual part of a tidal capture population [8,9], the retrograde part having spiralled in to coalescence and growth of the planets. A dynamically balanced population of tidal captures during outward motion will leave the protoplanet with its original spin direction, but slower. To achieve efficient tidal capture the need for nebular gas-drag assistance during the first pass further confirms that, bar the Mercury impact, the entire planetary construction process was accomplished within a nebula-present timescale - a not-unreasonable result in view of the big capture cross-section thereby offered.

This timescale (<5Ma?) rules out the supposed formation of planetary cores by percolation of molten iron, which would take >30Ma, but is consistent with the nebula-present mode of so doing [10,11], with the further great benefit of providing the otherwise-obscure source of the abundant SS water [11], including that subsequently carried out to the cometary belts. So the substantial detection of water in an exoplanet may have similar significance.

In summary, the very high orbital angular momenta of planets, w.r.t. their star, demands a scenario in which the motion of materials in the protoplanetary disc is **outward.** (A recent image of the Beta Pictoris young exoplanet system is persuasive visual evidence of such a flow pattern.) If a frame for doing that can be provided, all the other features discussed above could fall into place, and the Kant-Laplace paradigm be superseded.

To meet this demand, I will outline a 2-stage scenario [12,13] which embodies my finding that the Newtonian gravity field of a body is inevitably accompanied by a radial electric field, provisionally estimated at ~100V/m at the solar surface. In essence, when the plasma-rich protoplanetary disc was present, the Gravity-Electric (G-E) field would provide the outward drive and a.m.-enhancing force on protoplanetary materials. This scenario could even explain how the eccentricity of some exoplanets appears to have grown as their orbits grew. Final expulsion of the disc materials - a process portrayed in the Beta Pic image - allows the non-ionized elements of the system to adjust to the Keplerian state which now prevails. Evidently, the G-E field is the essential agent for the high a.m. of planetary orbits. Without it, the only planets anywhere would be close-in and ephemeral.

References

[1] Jeans JH (1919) Adams Prize Essay. Problems of cosmogony and stellar dynamics. *Clarendon Press.* 293 p.

[2] Lyttleton RA (1941) On the origin of the solar system. *MNRAS* 101, 216-226.

[3] Jeffreys H (1952) Bakerian lecture: The origin of the Solar System. *Proc.R.Soc.Lond.* A214(1118), 281-291.

[4] Spencer-Jones H (1956) The origin of the solar system. *PEPI* 1, 1-16.

[5] Gold T (1984) The early solar system and the rotation of the Sun. *Phil.Trans.R.Soc.Lond.* A313, 39-45.

[6] Cameron AGW & Benz W (1987) Planetary collision calculations: origin of Mercury. *Lun.Plan.Sci* XVIII, 151-152.

[7] Osmaston MF (2009) What can we learn about solar planetary construction and early evolution of the inner members of the system from their present dynamics? Importance of a 2-stage scenario. *EPSC Abstracts* 4, EPSC2009-265, 2009.

[8] McCord TB (1968) The loss of retrograde satellites in the solar system. *JGR* 73, 1497-1500.

[9] Counselman CC, III (1973) Outcomes of tidal evolution. *Ap.J.* 180, 307-314.

[10] Ringwood AE (1979) *Origin of the Earth and Moon*. Springer-Verlag.

[11] Osmaston MF (2010) Providing solar system water and high planetary angular momentum, using a return to Ringwood's core formation model, supported by the behavioural evolution of the mantle. *Geochim. Cosmochim. Acta* 74(S1), A 779.

[12] Osmaston MF (2011) A continuum theory (CT) of physical nature: towards a new ‘ground floor’ for physics and astronomy, including gravitation and

cosmogony, with major tangible support. In *Physical Interpretations of Relativity Theory, Proc. International Scientific Meeting - 'PIRT-2006', Sept. 2006, Imperial College, London. ISBN 9785703835500* (ed. MC Duffy, VO Gladyshev, AN Morozov, & P Rowlands), pp. 287-317. See also http://osmaston.org.uk.

[13] Osmaston MF (2012) Close-in exoplanets, but none of ours. Guidance from Triton's orbit and the physics of gravitation. *Session PL2, Exoplanets. UK-Germany NAM 2012, Manchester, UK.*