Planet X revamped after the discovery of the Sedna-like object 2012 VP_{113}?

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ABSTRACT

The recent discovery of the Sedna-like dwarf planet 2012 VP\textsubscript{113} by Trujillo and Sheppard has revamped the old-fashioned hypothesis that a still unseen trans-Plutonian object of planetary size, variously dubbed over the years as Planet X, Tyche, Thelisto, may lurk in the distant peripheries of the Solar System. This time, the presence of a super-Earth with mass $m_X = 2 - 15m_\oplus$ at a distance $d_X \approx 200 - 300$ astronomical units (AU) was proposed to explain the observed clustering of the arguments of perihelion $\omega$ near $\omega \approx 0^\circ$ but not $\omega \approx 180^\circ$ for Sedna, 2012 VP\textsubscript{113} and other minor bodies of the Solar System with perihelion distances $q > 30$ AU and semimajor axes $a > 150$ AU. Actually, such a scenario is strongly disfavored by the latest constraints $\Delta \varpi$ on the anomalous perihelion precessions of some Solar System’s planets obtained with the INPOP and EPM ephemerides. Indeed, they yield $d_X \gtrsim 496 - 570$ AU ($m_X = 2m_\oplus$), and $d_X \gtrsim 970 - 1111$ AU ($m_X = 15m_\oplus$). Much tighter constraints could be obtained in the near future from the New Horizons mission to Pluto.

Key words: Oort Cloud–Kuiper belt: general–gravitation–celestial mechanics–ephemerides

1 INTRODUCTION

Since the early work of Lowell (1915), the hypothesis that the remote peripheries of the Solar System may host a still unseen major body is regularly re-emerged over the years (see, e.g., Raup & Sepkoski 1984; Whitmire & Jackson 1984; Gomes et al. 2006; Lykawka & Mukal 2008; Iorio 2009; Melott & Bambach 2012; Matese & Whitmire 2011; Fernandez 2011; Lykawka 2012; Gomes & Soares 2013; Iorio 2012; 2013; Trujillo & Sheppard 2014), supported by a number of more or less sound indirect observational motivations ranging from alleged periodicities detected in paleontological fossil records on the Earth (Raup & Sepkoski 1984; Whitmire & Jackson 1984; Gomes et al. 2012; Iorio 2013; references therein). Among them, we mention that the dynamical action of a distant, isolated pointlike object as the one just introduced of the Solar System would produce an inner Oort cloud with distribution orbit between 200 and 300 AU. More precisely, numerical simulations showed that, while the presently known mass distribution of the Solar System came recently from the discovery of the Sedna-like dwarf planet 2012 VP\textsubscript{113} (Trujillo & Sheppard 2014). Indeed, Trujillo & Sheppard (2014) remarked that the clustering of the arguments of pericenter $\omega$ near 0° but not 180° for Sedna, 2012 VP\textsubscript{113} and other extreme Solar System’s bodies with perihelion distances $q > 30$ AU and semimajor axes $a > 150$ AU could not be attributed to an observational bias effect. As a viable candidate to explain such a pattern, Trujillo & Sheppard (2014) suggested the possible existence of a still unseen distant perturber in the form of a super-Earth ($m_X = 2 - 15m_\oplus$) rock-ice planet moving in a circular, low inclination orbit between 200 and 300 AU. Much tighter constraints could be obtained in the near future from the New Horizons mission to Pluto.

For other motivations supporting a PX scenario, see the Introduction of Iorio (2013) and references therein. Among them, we mention that the dynamical action of a distant, isolated pointlike mass can mimic the impact on Solar System’s major bodies of a specific kind of the subtle External Field Effect (EFE) arising...
in the framework of the MOdified Newtonian Dynamics (MOND) (Milgrom 2009; Iorio 2010; Blanchet & Novak 2011; Hees et al.

2 UPDATED CONSTRAINTS FROM THE PLANETARY PERIHELION PRECESSIONS

In his recent analysis of the all-sky survey with the WISE data, Luhman (2014) inferred tight lower bounds on the distance $d_X$ of putative far giant Saturn-like and Jupiter-like planets: $d_X \geq 28000$ AU for $m_X = m_{Sat}$, and $d_X \geq 82000$ AU for $m_X = m_{Jup}$, respectively. Moreover, he found that a Jupiter-mass brown dwarf cannot be located at less than 26000 AU. Actually, his analysis did not deal with rock-ice terrestrial planets as the one postulated by Trujillo & Sheppard (2014).

Model-independent, dynamical constraints on $d_X$ were inferred by Iorio (2012) for different values of $m_X$ from the upper bounds $\Delta \sigma$ on the anomalous secular precessions of the longitude of perihelion $\sigma$ of some known planets of the Solar System computed with earlier versions of the INPOP ephemerides (Fienga et al. 2010). Iorio (2012) preliminarily obtained $d_X \geq 250 - 450$ AU for $m_X = 0.7m_{Jup}$. Since it is $d_X \approx (m_X/\Delta \sigma)^{1/3}$ (Iorio 2012), it is straightforward to refine such estimates by using the latest results on $\Delta \sigma$ obtained with more recent planetary ephemerides (Fienga et al. 2011; Pitjeva & Pitjev 2013). From Figure 1 of Iorio (2012), it can be noticed that, for a given value of $m_X$ and by keeping the values of the perihelion of Earth, Mars and Saturn allows to constrain effectively $d_X$ for practically all values of the ecliptic longitude $\lambda_X$. In the case $m_X = 0.7m_{Jup}$ (Iorio 2012), the values by Pitjeva & Pitjev (2013) for the perihelion precessions of Mars and Saturn provide us with overall tighter bounds of the order of $d_X \geq 350 - 400$ AU. In turn, such revised bounds can be easily extended to the scenario proposed by Trujillo & Sheppard (2014); it turns out that $d_X \geq 496 - 570$ AU for $m_X = 2m_{Jup}$ and $d_X \geq 970 - 1111$ AU for $m_X = 15m_{Jup}$, respectively. Thus, the super-Earth scenario suggested in (Trujillo & Sheppard 2014) to explain the perihelion clustering of the known objects with $q > 30$ AU and $a > 150$ AU faces serious observational challenges.

Finally, it is worthwhile noticing that the New Horizons spacecraft en route to Pluto system should be able to put even tighter limits on the location of a putative trans-Plutonian object (Iorio 2013). Indeed, by assuming spacecraft’s range residuals as little as 10 m, it is possible to constrain the location of a super-Earth planet with $m_X = 0.7m_{Jup}$ down to about $d_X \geq 4700$ AU (Iorio 2013).

3 SUMMARY AND CONCLUSIONS

The hypothesis of a trans-Plutonian super-Earth ($m_X = 2 - 15m_{Jup}$) near the ecliptic at distances $d_X \approx 200 - 300$ AU put forth after the discovery of 2012 VP111 by Trujillo and Sheppard to explain the observed pattern of the perihelia of the Solar System’s objects with perihelion distances $q > 30$ AU and semimajor axes $a > 150$ AU is ruled out by the current bounds $\Delta \sigma$ on the anomalous secular perihelion precessions of some known planets of the Solar System.

Indeed, latest determinations of $\Delta \sigma$ by Pitjeva and Pitjev with the EPM ephemerides yield $d_X \geq 496 - 570$ AU for $m_X = 2m_{Jup}$, and $d_X \geq 970 - 1111$ AU for $m_X = 15m_{Jup}$.

The New Horizons spacecraft, currently en route to Pluto, should allow to constrain the distance of a putative body with $m_X = 0.7m_{Jup}$ down to $d_X \geq 4700$ AU.

REFERENCES

Blanchet L., Novak J., 2011, Monthly Notices of the Royal Astronomical Society, 412, 2530

Fernández J. A., 2011, The Astrophysical Journal, 726, 33

Fienga A., Laskar J., Kuchynka P., Le Poncin-Lafitte C., Manche H., Gastineau M., 2010, in Klioner S. A., Seidelmann P. K., Soffel M. H., eds, IAU Symposium Vol. 261 of IAU Symposium, Gravity tests with INPOP planetary ephemerides. pp 159–169

Fienga A., Laskar J., Kuchynka P., Manche H., Desvignes G., Gastineau M., Cognard I., Theureau G., 2011, Celestial Mechanics and Dynamical Astronomy, 111, 363

Gomes R. S., Matte J. J., Lissauer J. J., 2006, Icarus, 184, 589

Gomes R. S., Soares J. S., 2012, in AAS/Division of Dynamical Astronomy Meeting Vol. 43 of AAS/Division of Dynamical Astronomy Meeting, Signatures Of A Putative Planetary Mass Solar Companion On The Orbital Distribution Of Tao’s And Centaurs. p. #05.01

Hees A., Folkner W. M., Jacobson R. A., Park R. S., 2014, ArXiv e-prints

Iorio L., 2009, Monthly Notices of the Royal Astronomical Society, 400, 346

Iorio L., 2010, in Alimi J.-M., Füzfa A., eds, American Institute of Physics Conference Series Vol. 1241 of American Institute of Physics Conference Series, The Impact of the External Field Effect in the Modified Newtonian Dynamics on Solar System’s Orbits. pp 935–944

Iorio L., 2012, Celestial Mechanics and Dynamical Astronomy, 112, 117

Iorio L., 2013, Celestial Mechanics and Dynamical Astronomy, 116, 357

Lowell P., 1915, Memoirs of the Lowell Observatory, 1, 1

Luhman K. L., 2014, The Astrophysical Journal, 781, 4

Lykawka P. S., 2012, Monographs on Environment, Earth and Planets, 1, 121

Lykawka P. S., Mukai T., 2008, The Astronomical Journal, 135, 1161

Matase J. J., Whitmire D. P., 2011, Icarus, 211, 926

Melott A. L., Bambach R. K., 2010, Monthly Notices of the Royal Astronomical Society, 407, L99

Melott A. L., Bambach R. K., 2013, The Astrophysical Journal, 773, 6

Milgrom M., 2009, Monthly Notices of the Royal Astronomical Society, 399, 474

Pitjev E. V., Pitjev N. P., 2013, Monthly Notices of the Royal Astronomical Society, 432, 3431

Raup D. M., Sepkoski J. J., 1984, Proceedings of the National Academy of Science, 81, 801

Sheppard S. S., Udalski A., Trujillo C., Kubiak M., Pietrzynski G., Poleski R., Sozynski I., Szymański M. K., Ulaczyk K., 2011, The Astronomical Journal, 142, 98

Trujillo C. A., Sheppard S. S., 2014, Nature, 507, 471

Whitmire D. P., Jackson A. A., 1984, Nature, 308, 713

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