# Twitter Thread by Dr. Stephanie Deppe | she/hers

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@SpaceSciSteph

**My (probably) last co-authorship paper from grad school is out!!**

**The long story short is, any evidence for Planet Nine is gone. It doesn't exist.**

**This is the most comprehensive study EVER that examines the original clustering argument, led by @kjnapes. Let's get into it!**

■

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## No Evidence for Orbital Clustering in the Extreme Trans-Neptunian Objects

K. J. Napier,[1] D. W. Gerdes,[1,2] Hsing Wen Lin (林省文),[1] S. J. Hamilton,[1,*] G. M. Bernstein,[3] P. H. Bernardinelli,[3] T. M. C. Abbott,[4] M. Aguena,[5,6] J. Annis,[7] S. Avila,[8] D. Bacon,[9] E. Bertin,[10,11] D. Brooks,[12] D. L. Burke,[13,14] A. Carnero Rosell,[15,16] M. Carrasco Kind,[17,18] J. Carretero,[19] M. Costanzi,[20,21] L. N. da Costa,[6,22] J. De Vicente,[23] H. T. Diehl,[7] P. Doel,[12] S. Everett,[24] I. Ferrero,[25] P. Fosalba,[26,27] J. García-Bellido,[8] D. Gruen,[28,13,14] R. A. Gruendl,[17,18] G. Gutierrez,[7] D. L. Hollowood,[24] K. Honscheid,[29,30] B. Hoyle,[31,32,33] D. J. James,[34] S. Kent,[7,35] K. Kuehn,[36,37] N. Kuropatkin,[7] M. A. G. Maia,[6,22] F. Menanteau,[17,18] R. Miquel,[38,19] R. Morgan,[39] A. Palmese,[7,35] F. Paz-Chinchón,[40,18] A. A. Plazas,[41] E. Sanchez,[23] V. Scarpine,[7] S. Serrano,[26,27] I. Sevilla-Noarbe,[23] M. Smith,[42] E. Suchyta,[43] M. E. C. Swanson,[18] C. To,[28,13,14] A. R. Walker[4] and R.D. Wilkinson[44]
(DES Collaboration)

First, some background.

In 2014, astronomers Scott Sheppard and Chad Trujillo noted a weird clustering in the orbital elements of the most distant Kuiper Belt Objects they'd found. They hypothesized sorta in passing that a new planet could be responsible.

Enter Batygin & Brown

Mike Brown & Konstantin Batygin originally set out to DISPROVE the new planet hypothesis!

But instead, their simulations suggested a new planet, & even predicted its properties!

The resulting paper set off the biggest planetary debate of the century since Pluto's demotion.

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# EVIDENCE FOR A DISTANT GIANT PLANET IN THE SOLAR SYSTEM

Konstantin Batygin and Michael E. Brown
Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA; kbatygin@gps.caltech.edu
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## ABSTRACT

Recent analyses have shown that distant orbits within the scattered disk population of the Kuiper Belt exhibit an unexpected clustering in their respective arguments of perihelion. While several hypotheses have been put forward to explain this alignment, to date, a theoretical model that can successfully account for the observations remains elusive. In this work we show that the orbits of distant Kuiper Belt objects (KBOs) cluster not only in argument of perihelion, but also in physical space. We demonstrate that the perihelion positions and orbital planes of the objects are tightly confined and that such a clustering has only a probability of 0.007% to be due to chance, thus requiring a dynamical origin. We find that the observed orbital alignment can be maintained by a distant eccentric planet with mass $\gtrsim 10\, m_{\oplus}$ whose orbit lies in approximately the same plane as those of the distant KBOs, but whose perihelion is 180° away from the perihelia of the minor bodies. In addition to accounting for the observed orbital alignment, the existence of such a planet naturally explains the presence of high-perihelion Sedna-like objects, as well as the known collection of high semimajor axis objects with inclinations between 60° and 150° whose origin was previously unclear. Continued analysis of both distant and highly inclined outer solar system objects provides the opportunity for testing our hypothesis as well as further constraining the orbital elements and mass of the distant planet.

*Key words:* Kuiper Belt: general – planets and satellites: dynamical evolution and stability

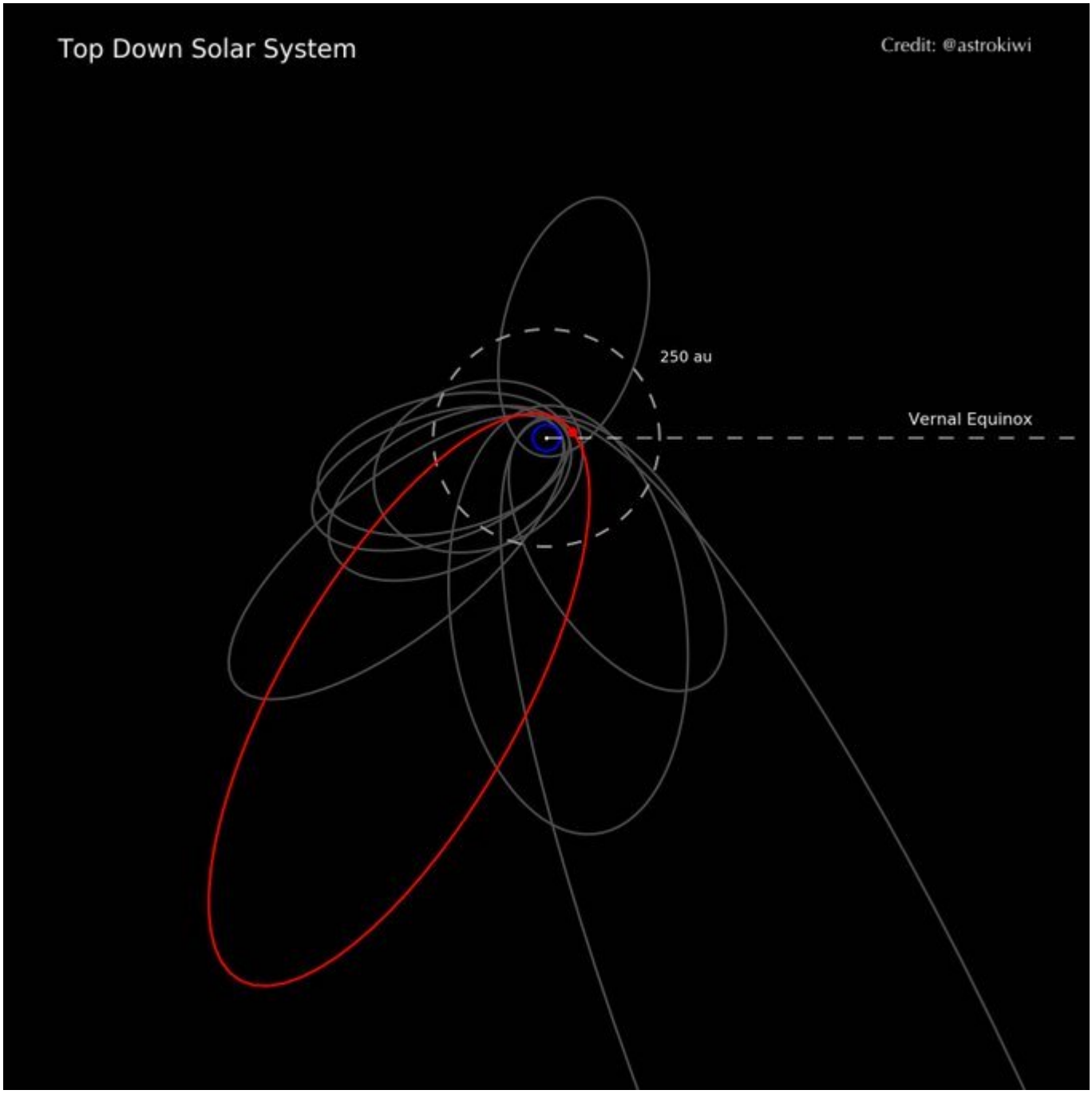
What's the debate?

Well, the argument for the last five years has all centered around the fact that you find objects where you look in the sky.

No surprise there, right?

This problem is complicated though, because the objects we're talking about have some of the most distant and elongated orbits of all the objects in the solar system.

We only find them when they're closest to the Sun, when they're at their brightest.




So if we only look at certain parts of the sky at certain times of year, we'll only find the objects that are in that part of the sky, at that time of year.

Which can lead to the APPEARANCE of clustered orbits that isn't actually REAL.

This effect is called selection bias.

The problem, and the root of the Planet Nine debate, is that most surveys don't make their selection biases publicly available.

You can't determine whether a particular object contributes to the clustering effect if you don't know the circumstances under which it was discovered!

The @OSSOSurvey has made this argument for the past five years. Their survey is the most meticulously documented and characterized survey I know of.

They know their selection biases EXTREMELY well. And that's thanks to @astrokiwi @sundogplanets and many others.

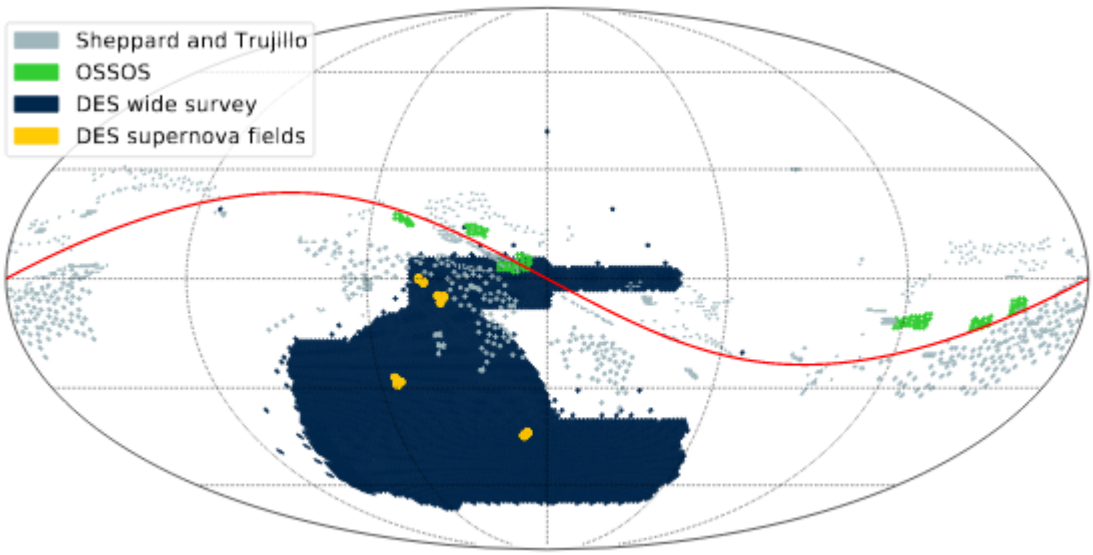
Now onto this most recent study.

A big issue with ALL of these studies is the small number of objects they consider.

The original hypothesis used 6.
OSSOS discovered 5.
My group with @theDESurvey discovered another 6.
A handful more were discovered by others.

As you can imagine, accounting for the selection biases of so many distinct groups is extremely difficult.

@kjnapes led a practically heroic effort to effectively combine OSSOS, @theDESurvey, and Sheppard & Trujillo's survey into one mega-survey.




The end result?

We're finding these very distant objects exactly where we expect to, based on where the telescopes pointed and when.

No funny business happening here. Therefore, no need for a new planet to explain anything!

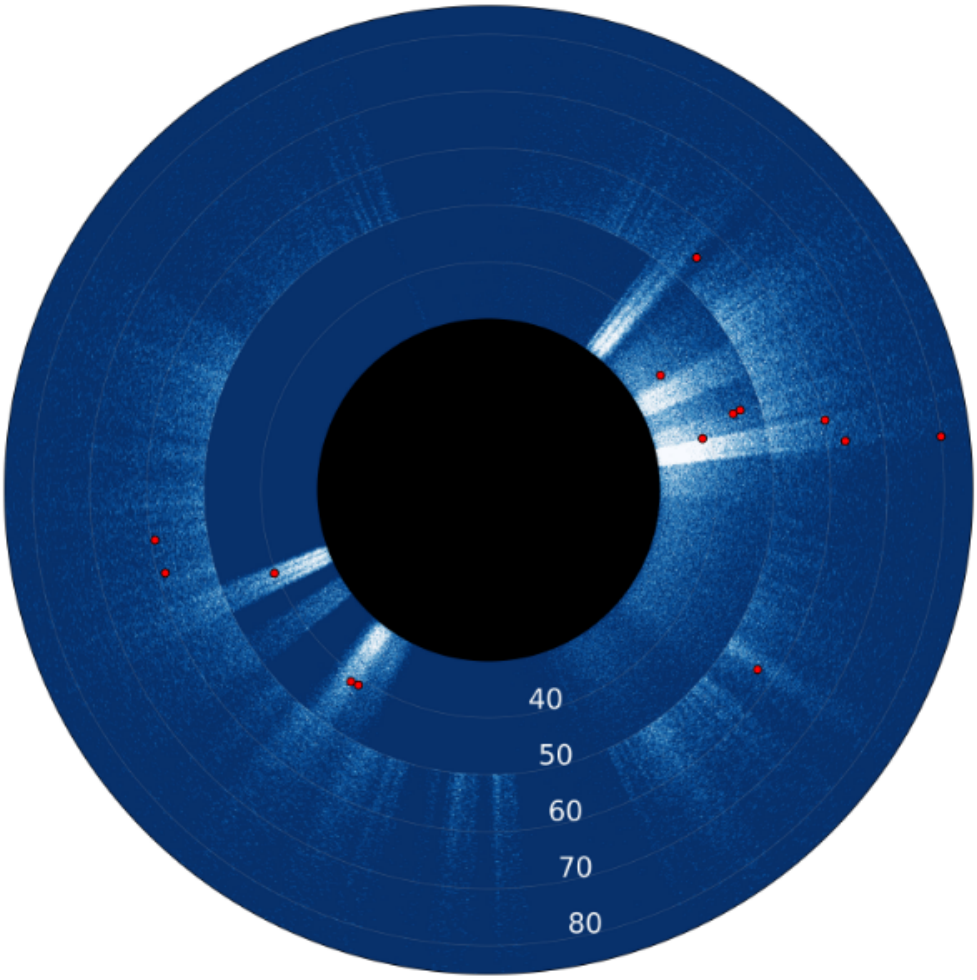



**Figure 6.** Combined ETNO selection function for all three surveys. The radial quantity is the ETNO's barycentric distance, and the azimuthal quantity is true longitude. The edge of the black circle is at 30 au. The white regions represent the combined surveys' sensitivity (brighter regions correspond to higher sensitivity), weighted by the number of real ETNO detections. The red dots represent the real ETNOs at the epoch of discovery. The outer ring is caused by the 50 au tracking criterion imposed by ST.

Now, there are a lot of dynamical arguments about Planet Nine (as opposed to the observational one here).

I'm not going to get into those bc 1) I'm not a dynamicist and 2) I've been out of the field for almost two years.

But this is a hit to the Planet Nine hypothesis for sure

Anyways, huge congrats to @kjnapes @dAArkEnergy and the rest of the group on this fantastic paper! I'm so happy to see it finally out in the world!

https://t.co/9Ggv9vRy5E