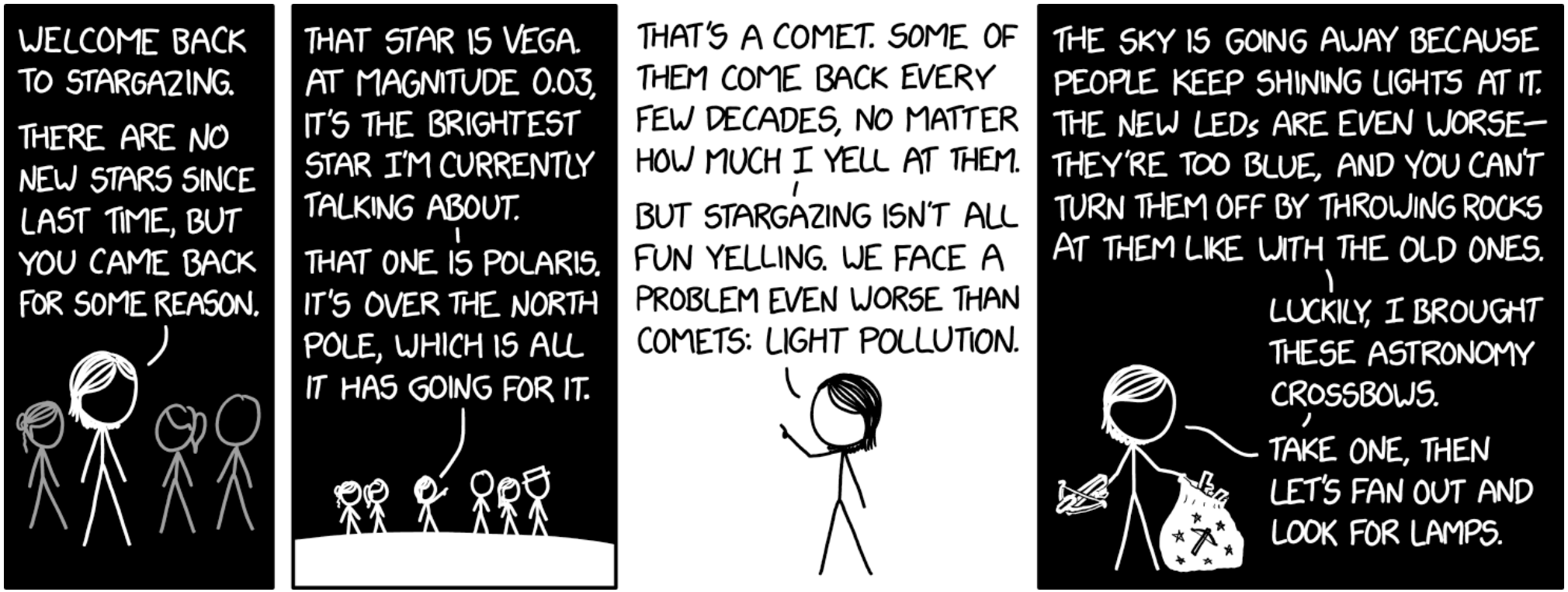
Planets Everywhere

Life, the Universe, and Everything.
Summary lecture for Learners, Feb 2020

Richard Edgar



"If we can destroy enough of the lights in our region, we may see more comets, but that's a risk we have to take."

From https://xkcd.com/2274/

Is there a Planet 9 in our solar system?

- Mike Brown, Caltech dynamical astronomer, is convinced the orbits of the large Kuiper Belt Objects are not random

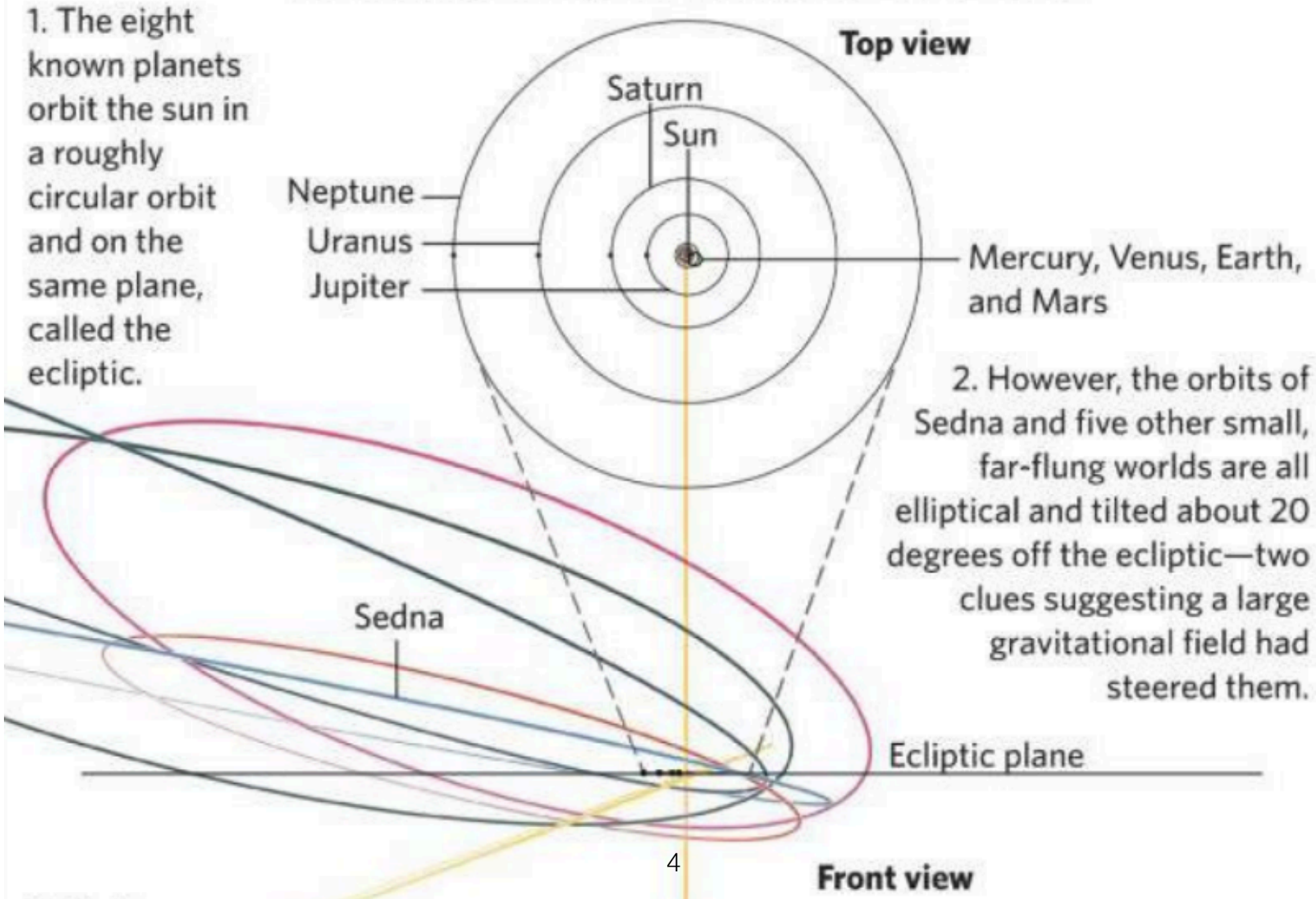
- He thinks they're herded into their elongated orbits which all more or less align by another planet of perhaps 10 earth masses far out in the Kuiper Belt.

- Simulations have settled on the mass and an approximate orbit for "Planet 9", but not where along the orbit to look.

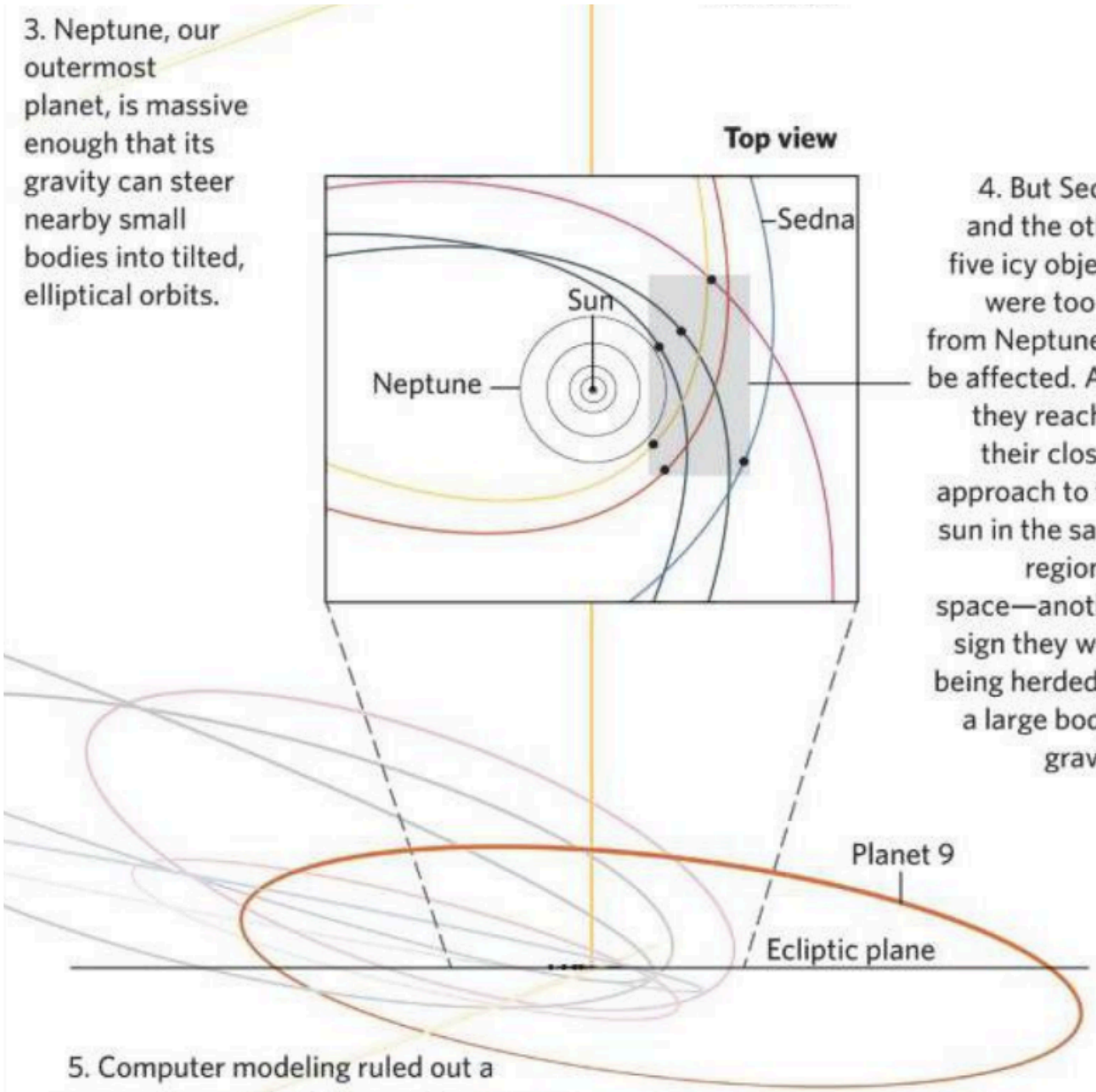
- Perhaps it'll show up in future searches, e.g. for earth-crossing asteroids.

THE CASE FOR PLANET 9

Beyond Neptune in the Kuiper belt, millions of small icy bodies orbit the sun. The odd, far-flung orbits of six of them were clues to a distant, massive planet, one that could forever change how we see our solar system. (Orbital data courtesy of Mike Brown.)



3. Neptune, our outermost planet, is massive enough that its gravity can steer nearby small bodies into tilted, elliptical orbits.



4. But Sedna and the other five icy objects were too far from Neptune to be affected. And they reached their closest approach to the sun in the same region of space—another sign they were being herded by a large body's gravity.

5. Computer modeling ruled out a passing star and other possible causes for the odd orbits, and showed there was just a 1 in 15,000 chance that the six bodies orbit this way by chance.

6. Instead, the six objects were likely being herded by a planet the size of Neptune and 10 times as massive as Earth that orbits the sun from far beyond Pluto.

Mass/Size gap in planets?

- In our solar system, there's no planet larger than the earth but smaller than Neptune (a factor of 4 in radius and 15 in mass).
- There are exoplanets in the gap, but even there, we find a smaller number around 2 earth radii.
- Perhaps this points to a different formation method for planets smaller than 1.5 earth radii, vs those larger than 3.
- So maybe our solar system is only a little bit weird.

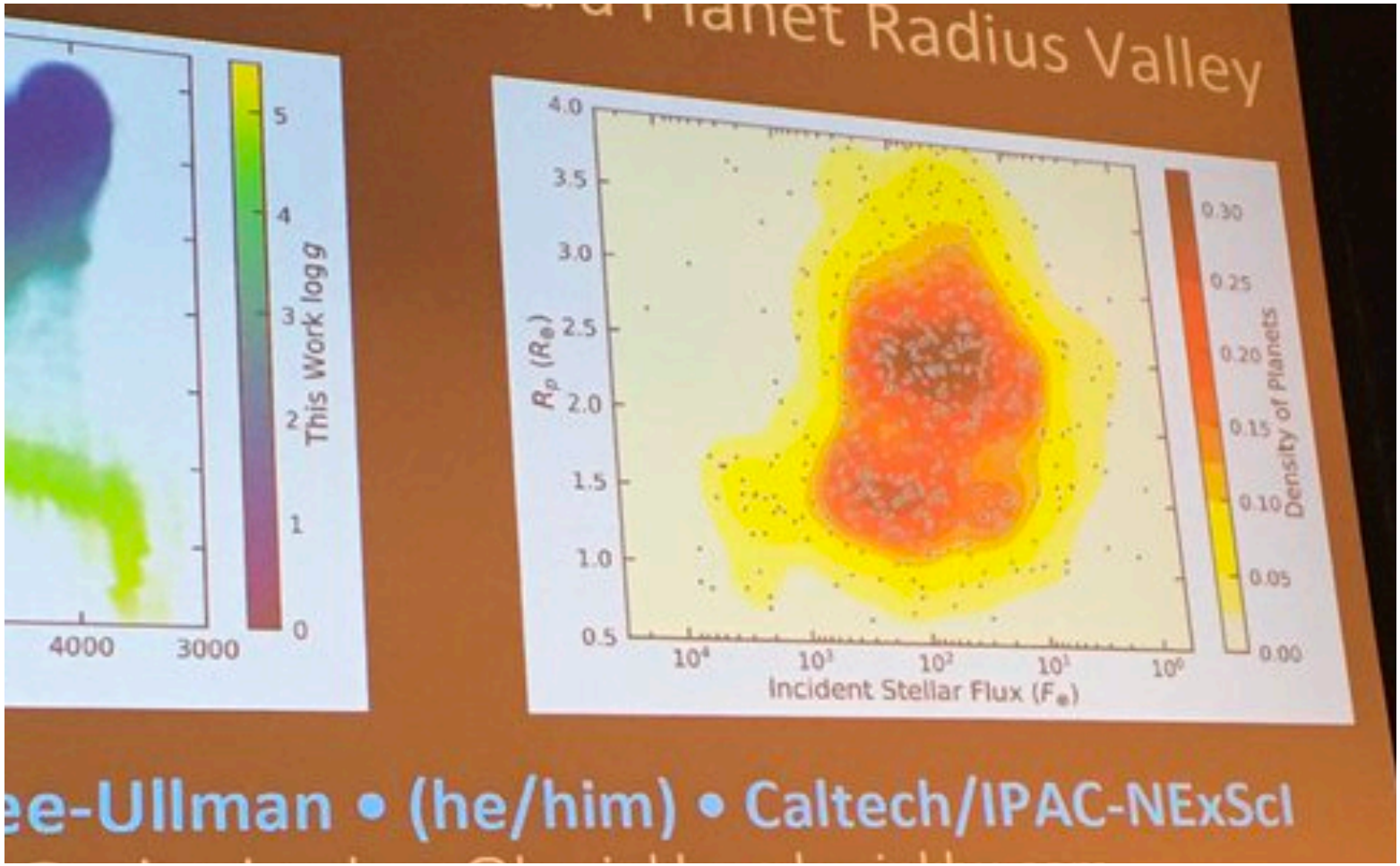
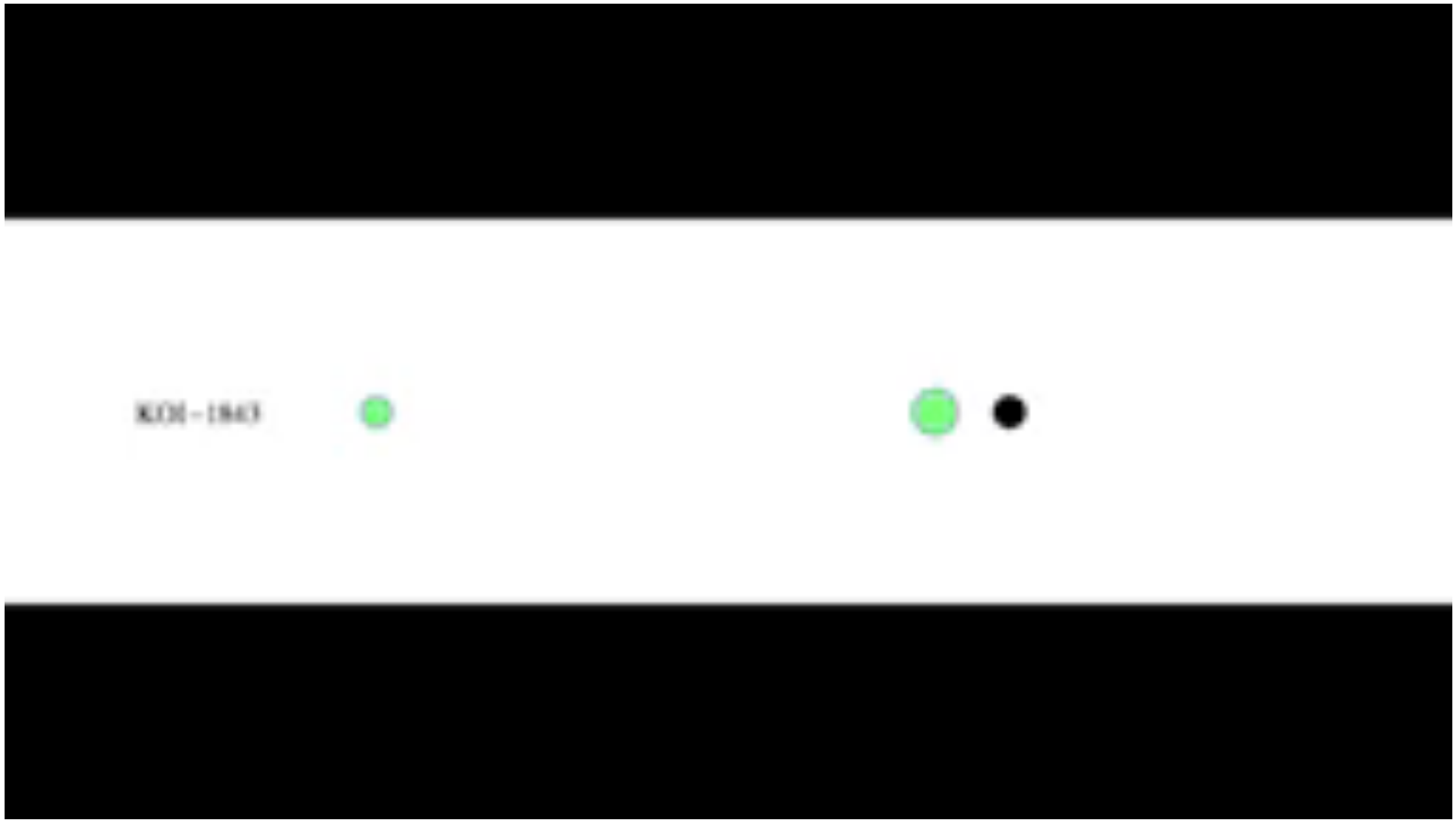


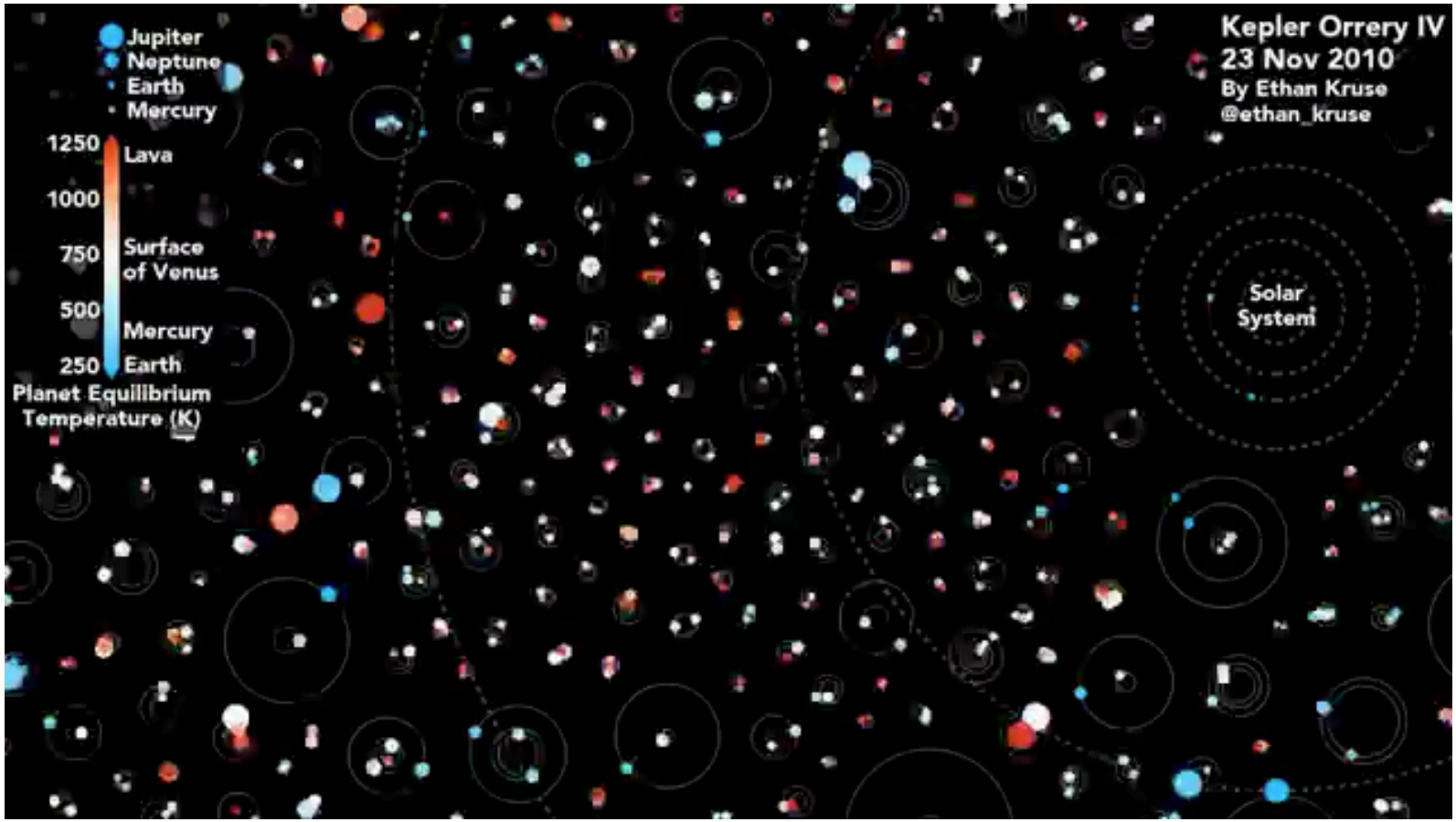
Diagram on right shows (in colors) how many known planets there are vs Stellar Flux (horizontal axis) and planet radius (vertical axis). Note the saddle around 1.8 earth radii.

From Kevin Hardigree-Ullman @ the January 2020 AAS meeting.



Visualizing orbits: Sound

https://eos.org/articles/set-to-music-exoplanets-reveal-insight-on-their-formation (Note KOI-4032 at 1:52 in the vid)



Visualizing orbits: The Kepler Orrery (2011)

Another visualization of lots of planetary systems, from Daniel Fabricky (Chicago).

Are there Exomoons?

- It seems likely… Moons are very common in our solar system.
- They are, however, hard to detect at great distance.
- The Cool Worlds Lab at Columbia has done a lot of simulations, trying to figure out what transiting planets with moons would look like.
- There was a suggestion of a Neptune-sized moon in orbit around a Jupiter-sized planet, but I think that turned out to be something else.
- Giant planets in habitable zones are (of course) easier to detect. Perhaps their moons would actually be habitable?

Probability of Life Forming?

- Still don’t have any clue.
- See the “Cool Worlds” video (which runs about 45 minutes) where Prof David Kipping (Columbia U.) talks at some length about why he thinks we don’t know.
- If, for example, it took a literal miracle, speculating on life elsewhere requires knowing the motivations of the creator. This is not a science question.
- The Anthropic Principle: The universe must be suitable for life, or we wouldn’t be here right now asking this question.

Things to remember

- Liquid water on the surface may not be required.
- For example life may be possible in under-ice ocean worlds, like Europa, Enceledus, others.
- Alternative chemistry might work. On the website there's a link to a (pretty technical) article on a kind of membrane that might self-assemble in Titan-like conditions (very cold, dominated by hydrocarbons, in an ethane/methane solution). Could this be used for cell membranes?

- Life is a self-replicating chemical factory. You might hear thermodynamical arguments against spontaneous biogenesis, but those laws refer to closed systems (no energy or matter in or out). Life is actually pretty good at generating entropy (randomness).

- Self-replicating systems need not decay into randomness before making many copies of themselves.

- Earth is special in a lot of ways (large moon so we have tides; magnetic field protects us from the sun …) Are any of those crucial to life?

- In the last 25 years or so, we've learned that planets are very common. There might be as many rocky planets in their habitable zones as there are stars.

- Our detection methods miss most of them, so there are probably a lot more than we see.

- Next generation instruments will help with atmosphere analysis and characterization of planet properties. Exoplanet climate research may also improve models of earth's climate.

- Stay tuned… this research field is in an exciting place!

Thanks for listening!

- Please fill out one of the course evaluation forms and return it in the envelope. I appreciate the feedback.
- I'm available for questions or discussions. Invite me to dinner, send an e-mail, talk to me in the hall, look me up in the directory.
- I'll (quite probably) be doing a course on current topics in astronomy in June.