Astrobiology News February 2015: Disorderly Planets

As recently as 20 years ago, the formation of planets around stars (like our Sun) was thought to be a fairly orderly process. A huge spinning interstellar cloud collapses via gravity into a proto-planetary disk, a large, flattened nebula of gas and dust. A star forms at the center of this disk, and planets form at various distances outward in the disk. Theory predicted that planets would orbit their stars in the same direction, on nearly circular orbits, and the composition of a planet should reflect where it formed in the disk. Planets orbiting near their stars would be made of refractory materials (mostly rock and iron, like Mercury, Venus, Earth, and Mars) that condense at high temperatures, while those orbiting further away would be huge gaseous planets containing volatile materials such as ices, as well as the most abundant elements, hydrogen and helium (like Jupiter, Saturn, Uranus, and Neptune). This nice, orderly process, stemming from some basic principles of physics and chemistry, came under close scrutiny as we actually started to find planets orbiting other stars (exoplanets), and we discovered that reality is a lot more complicated than this "simple" model.

Most of the exoplanet systems that have been discovered look very different from our own Solar System. There are exoplanets that don't orbit their star in the same plane, giant gaseous exoplanets so close to their stars that they complete full orbits in just a few days, and a class of exoplanets known as "super-Earths" that orbit at least 40% of nearby Sun-like stars, but have no analogs in our Solar System. It will take future large surveys, such as NASA's planned Transiting Exoplanet Survey Satellite (TESS),[1] to expand the range of candidates in order to investigate to what extent our Solar System may be different from other systems. Different techniques for identifying exoplanets are sensitive to different exoplanet sizes and orbits, so several methods need to be employed to build a picture of the architecture of other systems.

The phrase "consider a spherical cow" has long been a joke among theorists. It highlights a trade-off we often face as scientists – when does simplifying a problem become oversimplification? Generally speaking, when our models don't do a good job of reproducing real-world conditions, we know we're missing something important. Close encounters between forming planets may produce wildly eccentric orbits, and friction with gas in proto-planetary disks produces drag that may cause planets to "migrate" inward towards their stars, perhaps accounting for the close-orbiting giant exoplanets. Additionally, since most stars are born in clusters with many other stars, there may be many opportunities for nascent planetary systems to interact with each other through gravity.

[1] http://tess.gsfc.nasa.gov/

Through all of these complications, the “big picture” remains the same – stars and planets form from interstellar clouds of gas and dust, but the details that lead to the variety that we observe remain poorly understood. This is a great example of how science makes progress, and it is true in all fields. Through careful and repeated observations and experiments, we can often say with confidence that a certain process happens, without fully understanding the details of that process. Refining our observations and experiments allows us to build better models of nature; however, a model remains an imperfect reflection of the reality it seeks to portray – kind of like art!

In closing, I wanted to report that over 150 clergy joined us for our *Clergy Day* celebration at the Adler Planetarium in Chicago on February 10th – a truly outstanding showing! We had representatives from all of the Abrahamic traditions (at the very least) and we received lots of positive feedback. I hope your *Evolution Weekend* events were as exciting and successful!

Until next month,

Grace

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