Announcements

22 Oct 2013

Final Project

10-page written paper on a current topic in astrobiology.

Expect to read (and cite) ~5 research papers on the subject.

- Describe the issues
- Describe the controversy or debate
- What important work should be done to resolve the issue?

Your paper should be as quantitative as necessary.

I will help you find appropriate papers and references.

arXiv.org is a good place to start for articles, but I can provide access to additional articles.

Due end of semester

Example Topics

- In 2011, a paper in Nature claimed that **bacteria had been identified that** -- for the first time ever -- **used arsenic instead of phosphorous**. The paper was published to wide interest and criticism, and followup work does not support the original findings. What was the controversy, how was it handled, and what implications does this have for future work?

- In 1996, a paper in Science claimed that a **Martian meteorite held evidence for fossilized life** on that planet, drawing widespread interest from both scientists and the public. Since then, no more evidence has been uncovered. What is the state of this debate, what were the controversies, and what work in this area remains to be done?

- Saturn's moon Titan, which has extensive photochemistry but no water, has been claimed to be a potential habitat for life. **What are the arguments for and against life (or habitability) on Titan?** What future work should be done?

- Life on Earth is 'chiral' -- that is, **amino acids and DNA spiral in one direction**, but not in their chemically equivalent mirror image. **What is the source of this chirality on Earth?**

- **Titan, Enceladus, and Europa** are three targets in the solar system of great interest to astrobiologists. **Propose a mission** to one of these destinations, building on current spacecraft capabilities, and justify why you pick one of these. Be specific in your science goals, and your instrumentation to achieve those goals.

- Much work has focused on the ability of life to be created on Earth. It has also been proposed that **life was delivered here from another planet**, or another solar system. What are the relevant arguments in this debate on '**panspermia**'? Justify your position on the issue. What research should be done to address the controversy?

Water Planets

Water-Planets in the Habitable Zone: Atmospheric Chemistry, Observable Features, and the case of Kepler-62*e* and -62*f*

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Abstract: Planets composed of large quantities of water that reside in the habitable zone are expected to have distinct geophysics and geochemistry of their surfaces and atmospheres. We explore these properties motivated by two key questions: whether such planets could provide habitable conditions and whether they exhibit discernable spectral features that distinguish a water-planet from a rocky Earth-like planet. We show that the recently discovered planets Kepler-62*e* and -62*f* are the first viable candidates for habitable zone water-planet. We use these planets as test cases for discussing those differences in detail. We generate atmospheric spectral models and find that potentially habitable water-planets show a distinctive spectral fingerprint in transit depending on their position in the habitable zone.

Subject headings: Astrobiology - atmospheric effects - methods: data analysis – Earth - planets and satellites: general – stars: individual (Kepler)

1. Introduction

The possible existence of Earth and super-Earths[1]-size planets covered completely by a water envelope has long fascinated scientists and the general public alike (Kuchner 2003, Leger et al.2004, Selsis et al 2007). No such planets are known in the Solar System but small bodies like Pluto are composed of substantial quantities of water though none are in the HZ. Ocean-planets that form outside the ice line and migrate inwards to the Habitable Zone (HZ) and beyond were defined in detail by Selsis at al. (2007) in that broader sense and are now known to exist thanks to mean density measurements of a few transiting exoplanets (see e.g. Gautier et al.2012, Cochran et al.2011, Gilliland et al.2013).

Until recently all known candidates for ocean-planets (Borucki et al.2013) were found orbiting very close to their stars. Such planets, e.g., Kepler-18*b*,-20*b*,-68*b*, are very hot due to the high stellar flux, which ensures a smooth transition from an interior water envelope to a steam atmosphere with no liquid surface ocean (Rogers&Seager2010; Valencia et al.2009). The discovery of many planetary systems with tightly packed inner planets by the *Kepler* mission has opened the prospect for getting mean densities of Earth-size planets in the HZ by transit-timing variations (TTVs) where radial velocity amplitudes are too small to measure (Lissauer et al.2011). Given the very low mean densities measured so far among the majority of such planets, e.g. those found in Kepler-11 (Lissauer et al.2013), Kepler-20 (Gautier et al.2012), Kepler-36 (Carter et al.2012), we anticipate that the first HZ super-Earths of radius below 2 Earth radii (R_E) are more

[1] Super-Earth size is used here for planets with radii between 1.25 R. and 2.0 R..

Two of the most Earth-like planets found to date!

Don’t focus on details of spectroscopy.