SAG15 Telecon2

Survey of Potential High-level Science Questions

March 2, 2016

Status Update

First telecon Dec 15

AAS Presentation, feedback, website, 31 members

Second telecon March 2

Next telecons: Apr 6 and May 4 10-11AM MST

First goal: Initial set of High-level science questions

Present-Day Properties of Planetary Systems

What is the diversity of planetary architectures?

Observations: Sampling of orbital elements, radius/mass, density, irradiation, atmospheric composition,…?)

What are natural classes of exoplanets?

Observations: Search for clustering in N-dimensional space (Mass, density, irradiation, atmospheric composition,…?)

Includes:
- What is the chemical diversity and typical groups of exoplanets by composition? (atmospheres/bulk)

Are there typical classes/types of planetary system architectures ?

Are there sub-classes of planetary systems that are perhaps set by the systems dynamical evolution (undergoing a major instability or not?).

From Daniel Apai

Observables: Orbits, Mass, density

How Common is the Solar System?

How typical is the general orbital architecture and types of planets that are represented in the Solar System?
Understanding how planetary systems compare to the Solar System in general provides a context for our own planetary system and for the search for life.

From Maggie Turnbull, Daniel Apai

Observables: Orbits, Mass/Size, density, basic atmospheric composition,…?

Present-Day Properties of Planets

How do rotation periods and obliquity vary with orbital elements and planet mass/type?

Rotational periods are one of the fundamental timescales for atmospheric dynamics, diurnal variations of irradiation, and may have important impact on the maintaining a strong magnetic field in rocky planets. Obliquity plays an important role in climate models and may provide information on the late stages of planetary accretion.

From: Daniel Apai

Observables: Orbits, Mass/Radius, atmospheric composition, rotational and orbital phase mapping…?

What is the origin and composition of clouds and hazes and how do these vary with system parameters?

Clouds and hazes occur in most Solar System planets and formed through a number of different mechanisms, with condensation and UV-photochemistry being the dominant ones.
Clouds and hazes limit our ability to probe some of the exoplanet atmospheres, but also serve as indirect probes of the physical/chemical conditions in the atmospheres and constrain atmospheric circulation.
From: Daniel Apai

Observables: Orbits, Mass/Radius, atmospheric composition, rotational phase mapping

How does atmospheric circulation and heat transport vary with system parameters?

Over a larger sample of orbital radius and planetary sizes (mass;radius), we need to answer time variability of composition and temperature.

At certain distances from the central star, the heat distribution moves from zonal winds to convection zones. This can be observed as an atmosphere of differing temperatures and spectral mixing. Can this chemistry and radiation be out of phase in the orbit or rotation (lag times, etc), and what does heat redistribution depend strongest upon? This points back to basic formation principles as well as how the general distribution within orbits and eccentricities affects the planets.

I think you need direct imaging and spectral observations of these planets throughout the orbit and rotations. I don't know if it can all be done in the visual, as some of the best star/planet flux ratio as well as spectral indicators (CO, CH_4) are in the infrared.
From: Patrick Lawrence

Observables: Orbits, Mass/Radius, atmospheric composition, rotational and orbital phase mapping…?

Which rocky planets have liquid water on their surfaces?

The key question for me concerns the availability of liquid water on the surfaces of rocky planets orbiting other stars. Water is not a biosignature itself, but the presence of liquid water is required for life as we know it. And life as we know it is probably the only kind of life that we may be able to identify remotely. Liquid water is not the only factor required for planetary habitability, but it is arguably the most important one.

Related observables: 1) orbital distance. It is critical to determine the semi-major axes of rocky exoplanets because this plays a key role in determining whether they can support liquid water on their surfaces. Note that this likely requires multiple revisits to each planetary system of interest. On TPF-C, we assumed 5-6 revisits per system. 2) Gaseous CO2 and H2O. Both of these gases are potentially observable at near-IR wavelengths. CO2 is even easier to observe in the thermal-IR, but that requires a different kind of direct imaging mission.
From Jim Kasting

Irradiation (Orbital elements), CO2 and H2O abundances; Size, Atmospheric Pressure, Water Partial Pressure, Surface Gravity

Multi-band/Spectral rotational phase mapping?

What types/which planets have large continents and oceans?
What types/which planets have active continent-forming or resurfacing processes?

Observables: Multi-band phase mapping, orbits, mass, density, atmospheric composition,…?

Giant Planets and Moons

Which giant planets have Earth-sized moons?
How frequently, if at all, do such objects form?

Observables: Orbits, Mass, density, atmospheric composition,…?

Formation and Evolution

Key Mechanisms in Rocky Planet Evolution

In other words, which aspects of planet formation (mass, spin, composition) impact which aspects of planetary atmospheres and climate?
This is a classic nature vs nurture problem. Maybe the most important determinant of a planet's evolution is the final major impact, or its star's UV flux, or maybe it is the planet's volatile content... or maybe it is first-order stochastic with only second-order correlations to the factors above. Another way to think about the effect of nurture is the extent to which planets exhibit hysteresis. If Earth and Venus traded locations, would the new cooler Venus end up looking more Earth-like in the long run, and vice versa.
From N. Cowan

Observables: Orbits, Mass, density, atmospheric composition,…?

What is the Transition Region for Extreme Water Loss?

What is the transition region for a planet in the HZ to a planet that is undergoing extreme water loss, around a star? In other words, is the transition between a habitable planet like Earth, and a dessicated planet like Venus smooth? How does this transition region depend on the stellar type?

The reason I think it is important is because, with direct imaging missions, we can not only characterize Earths but exo-Venus' too. Observing this transition region potentially can tell us if the evolutionary history of Earth and Venus in our Solar system is unique or common (around different spectral types).

From Ravi Kopparapu

Observables: Orbits, Mass, density, atmospheric composition,…?

How are the formation pathways for Gas/Ice Giants influence their bulk compositions?

Observations: Mass and orbital semi-major axis distribution, key atmospheric absorbers

How Important is Disk Migration of Planets?

What is the stopping mechanism?

Observations: Mass and orbital semi-major axis distribution

How Important is Post-formation Planetary Migration?

Observations: Resonant planets