Minutes of the SAG15 2nd Telecon, March 2, 2016

Prepared by Daniel Apai; If you have any addition or correction, please email to apai@arizona.edu

Present:
Daniel Apai (DA)
Shawn Domagal-Goldman (SDG)
Steve Kane (SK)
Theodora Karalidi (TK)
Avi Mandell (AM)
Ravi Kopparapu (RK)
Caroline Morley (CM)
Leslie Rogers (LR)
Mark Swain (MS)

The slides for the SAG15 Telecon 2 are posted on the SAG15 website: http://eos-nexus.org/sag15/

DA summarizes status and next steps for SAG15:
- Charge is to provide a mission-independent assessment of the key science questions direct imaging missions could/should answer and determine the type and quality of data required for answering these questions. Detailed charge is available on website.
- DA presented SAG15 status on AAS and received important feedback, which resulted in multiple new calls for members (significantly strengthening SAG15 team), a website dedicated to provide up-to-date status information.
- Immediate goal: identify initial list of high-level science questions
- Next telecons: April 6 and May 4 at 10-11AM MST

DA: The slides combine input from various SAG15 members and attempt to provide a list of high-level questions to discuss at this telecon and in next days.
Questions are organized in three themes: Planetary System Architectures, Present-day Exoplanet Properties, Formation/Evolution .

Question: What is the diversity of planetary architectures?

Comments:
Swain: For this question supporting measurements from other methods are important. Are we going to discuss these?
DA: Yes, absolutely; we can identify how different complementary measurements help answer the questions we are identifying.
SDG: There will be an upcoming white paper by Debra Fischer and colleagues on high-precision RV measurements that will be very relevant for this question.
SDG: Rather than identifying a complete understanding of planetary architectures (which may be impossible to achieve), we may want to identify specific hypotheses that should be tested. For example, a hypothesis on the transition between rocky planets and gas giants could have specific, testable predictions.

Questions: What are natural classes of exoplanets? Are there typical classes/ types of planetary architectures?

SDG: We should also consider that, given also complementary measurements, which dimensions of the description of planetary architectures are important and which are not probed sufficiently by existing/future measurements, i.e., prioritize dimensions that are important and unexplored.

SK: We should consider dynamical constraints, such as mean-motion resonances, on the N-dim parameter space, as the dynamical information can be important for understanding the systems.
SK: A related question: are compact planetary systems extremely common? There are some biases and intriguing trends in the existing transit-based data that could be verified with direct imaging.

Question: How Common is the Solar System?

SK? : Jupiter analogs are becoming detectable and this question (at least frequency of Sun-Jupiter pairs) will be answered relatively soon.
DA: There are many parameters that could be used to determine the similarity of a given planetary system and the Solar System; not clear which are more important than others for our purposes and how to weight them.
Consensus: We will need to better define this question.

Question: How do rotation periods and obliquity vary with orbital elements and planet mass/type?
RK: Not clear how these could be measured.
DA: Rotation periods could be directly measured from time-resolved precision photometry. Obliquity is much more difficult, but was shown that it could be constrained from the combination of orbital phase and rotational phase maps.

SK: We are carrying out a study using the Earth-observing EPIC camera to study Earth as exoplanet. We will also demonstrate how rotational rate can be determined and what other parameters can be constrained.
RK: Rotation rate is also important for habitability calculations; most current calculations just assume Earth-like rotation rate.

Consensus: Useful question.

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

MS:The most interesting aspect of this and many other questions is to characterize/ understand the processes responsible for the properties of the planets.
DA: I agree; I separated questions that focus on understanding processes into a third category (Evolution/Formation). The rationale for this is that understanding processes may require a certain sample size, while characterizing individual planets does not.

RK? : It could be interesting and important to identify which planets have primary vs. secondary atmospheres. This may involve understanding the evolution of the planet's orbit, i.e., migration.

LR: Does SAG15 has enough expertise in planetary dynamics? Do we need to add dynamicists?
SK: I have projects on planetary dynamics and can help to an extent.

Question: How does atmospheric circulation and heat transport vary with system parameters?
SK: A lot can be learned from planets on eccentric orbits; we should consider current and future observations of such systems.

SDG?: The question implies a large survey that may not be suitable for a limited mission. Instead, we should ask a more focused question, such as "What drives atmospheric circulation and heat transport?"

MS: These questions are all interesting, but not all equally important; it is clear that some of these would not be science objectives for missions. We may want to classify them as questions with primary vs. secondary importance.
DA: I absolutely agree. Part of the motivation of SAG15 is to explore the breadth of science questions that could be learned from direct imaging missions, even if these are not the science drivers. For example, searching for a biosignature on an Earth analog could take a week of integration to build up the signal: in the meantime, many other, brighter planets may be in the field of view, on which we can collect spectra and time-resolved photometry for free. We should make sure that the instruments we build also consider the non-primary science objectives, if possible, so we don't miss science opportunities.

Question: Which rocky planets have liquid water on their surfaces?
Consensus: Important question.
Multiple people: Presence of water may be constrained through measurements other than atmospheric spectroscopy; rotational phase mapping, for example, could be important.
RK: Determining P-T profile and presence of water clouds would also be important/useful.
SDG: This question connects well to SAG16, where we study biosignatures. Liquid water on the planetary surface is a habitability signature, which is not studied in SAG16; SAG16 will rely on SAG15 for this context.

Question: What types/which planets have large continents and oceans?
Question: What types/which planets have active continent forming or resurfacing processes?
DA: These may be speculative questions; but simulated/observed Earth time-resolved multi-band photometry (Cowan et al., and others) show that in principle one could identify continents and oceans from phase mapping. I think we should consider what deeper questions can we answer with these potential observables. For example, on a planet with active hydrological cycle continents are constantly and gradually eroded. Perhaps one could make an argument that planets with large continents must have active continent-forming processes, such as plate tectonics.

Multiple people: There are other important processes that could potentially be constrained and would be very important.

RK: Constraining interior heat and heat transfer would be very important. Volcanic activity would be interesting.
SDG: RK, myself, and other colleagues are working on a project to see how volcanically emitted gases could be detected. Nevertheless, probably such gases, if present, are undetectable at Earth-like levels.
SDG: One could explore that, given certain interior processes are active, what would be their impact on the observational results.
Multiple people: Other factors that could be important include elemental compositions, such as Si/Mg ratios.
SDG: Range of sub-surface process may be sensitive to bulk compositions, as discussed in the Upstairs/Downstairs workshop recently. We should reach out to the NExSS Earth Science community and involve them in this discussion.

DA: Are there other questions/problems that we should include?

Steve:
- Migration:
SK: If we could determine the ages of systems, we could explore planetary architectures as a function of time constrain to constrain migration or planetayr orbit re-arrangements.

LR: We did not include or mention disks and minor body populations. These could provide important clues on the architecture and evolutionary history of the systems.
DA: I agree; we should add this.

DA: As our next step, I will update our SAG15 report working draft based on our discussion and will circulate it for comments and additional input. On our next telecon we will discuss the updated draft and will begin the process of identifying the different observational pathways to inform the questions.

Chat Window Content:
Shawn Domagal-Goldman: Here is the website: http://eos-nexus.org/sag15/

Ravi Kopparapu: Shawn: Can we identify haze composition with direct imaging?
Shawn Domagal-Goldman: Ravi, it depends on the haze and the wavelength range of the direct imaging mission. 😉
Shawn Domagal-Goldman: (what Mark just said)
Ravi Kopparapu: yes, of course!
Ravi Kopparapu: right!
Shawn Domagal-Goldman: The Charney et al. paper discusses this. Giada's paper, when it comes out, will also do so. Stephen Kane: Presumably restricted to haze in the upper atmosphere depending on the scale height.
Shawn Domagal-Goldman: And Hannah Wakeford has some excellent thoughts on this.
Ravi Kopparapu: will talk with her.