Summary of discussion session on Star and Planet Formation and Evolution at 49th ESLAB Symposium "Exploring the Universe with JWST"

These are the notes summarizing the discussion session on star and planet formation and evolution, organized by Rachel Osten (STScI), Catarina Alves de Oliveira (ESA/STScI), and Inga Kamp (Kapteyn Institute, University of Gronigen). The format of the discussion was to break into small groups, with each group focusing on one topic. After a suitable amount of time, the groups reconvened for a summary and additional discussion by the wider audience. Four questions were discussed:

1. Need for pre-launch data. Are people aware they may need pre-imaging observations with either NIRCAM or Hubble, as precursor images to prepare NIRSpec/MSA observations? What other kinds of supporting data are needed to maximize the scientific return of JWST? Are there mechanisms in place to obtain this data, or is a coordinated effort (for instance at the Project level) needed?

The small group which discussed this issue did not think the community is fully aware that for MOS spectroscopy one may need pre-imaging, and that there is a trade-off between accuracy of target coordinates and the amount of slit losses and the accuracy level of radiometric corrections. Because of the required accuracies, HST and NIRCam are indeed the only possibilities to get accurate positions. There was discussion about the need to set aside some time on HST to do this, especially since some targets are too bright for NIRCam. There were comments from STScI that indeed such a "JWST Preparatory Science" category is being discussed beginning possibly as soon as HST cycle 24. A related question came up about the turnaround time needed from the pre-imaging observations to fully specify MOS observations, and whether this could be accomplished in the same JWST proposal cycle.

There was some discussion about whether ALMA and Gaia could give accurate positions for bright targets, but it was unclear whether the magnitude range for Gaia would be useful for star formation science cases. And for ALMA there was a statement that the accuracy of fractions of arc seconds might be sufficient for some science cases.

The need for accurate ephemerides for transiting exoplanets was another topic that came up for discussion as supporting data; contemporaneous observations with TESS or CHEOPS will be necessary to determine the phasing of primary and secondary eclipses sufficiently accurately to plan observations.

Other types of supporting data mentioned to maximize the science return were the high backgrounds typical of star formation regions needing to be included in the exposure time calculators to account for the glowing background of the ISM.

2. Which are the key science topics that gain most from multi-wavelength synergy with other facilities? Which are the current or upcoming facilities that should be used in coordination with JWST, e.g. in a joint proposal scheme?

Multi-wavelength observations were deemed critical for many or most of the science cases in the topic of star formation. The synergy between JWST and ALMA was judged to be very important, so much so that there was a strong sentiment for joint proposals between ALMA and JWST. Ancillary data with HST was also seen as crucial for star and planet formation, as well as GMT and 30-m class telescopes. SPHERE and GPI were discussed in terms of complementarity with mid-IR observations of disks and transiting exoplanets. Transient phenomena was seen as requiring a higher degree of multi-wavelength observations.

3. What do you see as the optimal mix of small to large programs for accomplishing the science in formation and evolution of stars and planets? What is the right sample size needed to accomplish the science objectives? JWST instruments are complementary to each other in many ways (e.g. resolution, wavelength coverage) and may be used in parallel. When observing a particular target, do you envision to make use of a suite of instruments, or to explore a single operating mode?

Large programs were seen as being essential to accomplish the science objectives; a big question cannot be answered with a small sample, which applies to all areas of star and planet formation. Large programs in addition can potentially optimize efficiencies and decrease overheads, therefore maximizing the time for science. Spitzer and Herschel can and will continue to be used as discovery machines, and many of the JWST targets for star and planet formation will be coming from these missions. Parallel observations were deemed to be extremely useful, with spectroscopy and imaging combinations (e.g. NIRSpec and MIRI) noted as a particular way to combine instruments in parallel, in addition to MIRI and NIRCam mapping in parallel mode.

4. JWST will offer a broad suite of instruments, each with several observing modes (e.g. multi-object spectroscopy, several IFUs, two coronagraphs, aperture-masking interferometry, slitless spectroscopy, etc.). STScI is working on developing JWST data analysis tools. Do you plan to use this toolbox, or do you plan on using/developing tools specifically for your own science case? Are you aware of community input sought for development of

data analysis tools and training? What should the priority of data analysis tool development be for this science area?

On the topic of data analysis tools, the strong sentiment was expressed that training in the tools was just as important, if not more important, as the tools themselves. Because both the pipeline and data analysis tools will be written in Python, it is important to make sure that users are trained in these tools before JWST starts producing data. There was clear support for the annual data analysis workshops. Modularity of pipeline and tools was seen as important, so a user can decide at what level to carry on by oneself and to be able to dig into the data. The steps in the pipeline processing and the levels of processed data that will be produced need to be explained better, as well as the interface between where the pipeline processing stops and further data analysis begins.

5. Other topics.

Another topic brought up for discussion was the synergy between local, Galactic topics of star formation, and connection to extragalactic star formation studies. JWST will be able to probe nearby galaxies in the same way that Spitzer could for local star formation regions, but it was not clear that the two communities are talking about synergies and lessons to be applied from one community to the other in anticipation of JWST.