Frontier Science Opportunities with the *James Webb Space Telescope*

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The Space Telescope Science Institute hosted the "Frontier Science Opportunities with *JWST*" meeting on June 6–8, 2011. The meeting brought together nearly 200 astronomers from around the world, including many students and postdoctoral researchers. The goal of the meeting was to critically review the science potential of *JWST*. The meeting also provided an opportunity to educate the next generation of astronomers about the role that *JWST* is expected to play in addressing the top science questions outlined by Astro2010, the recent decadal survey of astronomy and astrophysics.

The three-day meeting on *JWST* was a mix of invited and contributed talks spanning virtually every aspect of modern astronomical research. An imposed limit on the length of presentations ensured that more than one-third of the total time was devoted to discussions between the audience and the speakers. As a result, most talks were followed by in-depth analyses of how specific science topics could be addressed by *JWST*. In addition, these discussions identified a variety of implicit support requirements for the *JWST* science program, such as the need for pipeline scripts to efficiently reduce spectroscopic data obtained by an integral field unit and multi-object spectrograph, software tools to analyze coronographic observations, and steps that might be taken to ensure the availability of the multispectral observations, from short to long wavelengths, that will be needed to provide context and identifications for *JWST* observations.

The range of science presented at the Frontiers meeting vivified the unique role that *JWST* will play across the frontiers of astronomy, from studying of our Solar-System neighbors to probing the distant beginnings of time. Spectroscopic observations of Neptune and Uranus using the Mid-Infrared Instrument (MIRI), to take atmospheric temperatures and shed light on cloud dynamics, might be followed in the observing schedule by deep searches for the first cosmic explosions, at the edge of the observable universe. The audience heard about new models that predict the blast profiles and light curves of core-collapsed and pair-instability supernovae, which suggest that *JWST* would capture a predicted late-time rise of the radiation as the fireball expands and cools over a span of greater than 300 days. The synergy between *JWST* imaging and future spectroscopy from ground-based telescopes in the 25-meter-class, which could observe diagnostic spectral lines of supernovae at an early stage, will help distinguish between different progenitor classes.

The newly released, prototype exposure-time calculators (ETCs) for *JWST* (http://jwstetc.stsci.edu/etc/) were an advantage to speakers, allowing them to establish the feasibility of their science programs. The ETCs revealed, for example, that the Near-Infrared Camera will measure the stellar mass function down to cool stars near the hydrogen-burning limit in stellar populations out to 25 kpc in less than ten thousand seconds of exposure time. Spectroscopy with the Near-Infrared Spectrograph will detect the phase curve of exoplanets around nearby M dwarfs in an hour of exposure, and also provide the first opportunity to

characterize water features in the atmosphere of "ocean" planets with longer integrations. MIRI will provide sufficient sensitivity and angular resolution to map the 10- and 20-micron silicate emission features generated by circumstellar dust grains in debris disks in just several hours of exposure time. Sensitive imaging from *JWST* will also advance dark-energy research, and characterize departures from a flat universe through measurements of the Hubble constant with ~1% accuracy. Such an investigation would require a few hundred hours of surveying.

The Frontiers meeting provided interesting insights on the core science themes of *JWST*. For example, several speakers emphasized that the search for the earliest galaxies requires criteria to ensure confidence that we have indeed found the earliest galaxies. One spectroscopic criterion would be the detection of [He II] and the non-detection of [O III]. Gravitational lensing at magnifications over 20 could measure galactic structure, test density profiles, and disentangle active galactic nuclei and star formation.

Infrared observations by *JWST* will clarify whether the integrated extragalactic background is related to energetic galaxy formation or poor subtraction of zodiacal foreground.

The *Kepler* mission has discovered a zoo of planetary candidates in our own Galaxy. Follow-up observations of exoplanet transits and eclipses by *JWST* will clarify planetary sizes and provide information about atmospheric composition and thermal structure.

One highlight of the meeting was a special, rapid-fire poster session in which over 20 presenters gave one minute advertisements of their posters to the full audience of meeting participants. For many in the audience, this session connected research to faces, and led to enhanced discussion and interaction in the poster room during breaks.

Another highlight was a special session for the *JWST* instrument PIs to give the status of their instruments, and to summarize the recent work of their teams on calibration. Each PI reviewed instrument's technical performance and scientific expectations.

All presentations can be viewed on the Institute webcast site (https://webcast.stsci.edu/webcast/), and the slides can be downloaded.

The Frontier meeting demonstrated the astronomical community's high interest in the *JWST* project. There was general agreement that resolving many of the most important issues in astrophysics calls for the sensitivity and resolution of *JWST*'s imaging, spectroscopic, and coronographic modes.

The Institute's *JWST* team welcomes community involvement and has opened up a forum for astronomers to provide feedback, which might include science-operational ideas for exploiting the telescope, or other ideas on how the best science will be achieved. To contribute, please visit http://jwstinput.wikidot.com/ and or email us at jwst_input@stsci.edu.


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