Keck Science strategic Plan

Solar System: Giants

Gordon Bjoraker, Imke de Pater, Mike Wong, Sara Faggi, Giuliano Liuzzi, Vincent Kofman, and Geronimo Villanueva

Jupiter and Saturn are dynamic planets with constantly changing cloud structure. High spectral resolution observations of these planets at 5 μm provide important information on the gas composition and cloud structure at levels deeper than the visible cloud deck.

What critical instrumentation capabilities should Keck Observatory develop or maintain on 10 to 15-year timescales?

Following the needs of the planetary community, as summarized in the table here below, the primary instrument capabilities that Keck Observatory should maintain are:

	Requirements	Comments
Wavelength coverage:	**1 – 5 μm**	The 1-5 μm (in particular, **3 – 5 μm region**) provides competitive sensitivities to space and broad molecular capabilities.
Spectral Resolution:	**>20,000 (minimum) >50,000 (optimal)**	Molecular investigations require **high-resolution spectroscopy (R >10,000).** Optimal it would be R > 50,000
Slit length / width:	**25″ optimal**	**Long-slit** spectroscopy, wide FOVs and/or IFU capabilities are essential for mapping. Slit length **> 15" is required** at least in LM, ~ **25" is optimal**. Possibility to choose between different slit widths is also important.
Guiding:	**Non-sidereal guiding**	**Non-sidereal active guiding** capabilities are essential, the selection of multiple wavelengths, independent of the operational wavelength of the spectrograph could be incredibly helpful.
Adaptive Optics	**Needed/Desired**	This would be **very important** with both point sources and extended objects. For example, it will be essential for objects like Uranus and Neptune, and small satellites (like Io), for investigations at 1-2.5 μm. AO for Jupiter and Saturn is desired, it will require a satellite nearby for wavefront sensing, or a laser.

It is important to preserve the capability of **mapping** these planets using **long-slit spectrometers**. Currently Keck/NIRSPEC has a 24″ slit, probably the longest slit available at IR wavelengths in the northern hemisphere. This permits hemispheric studies of Jupiter (48″ diameter); two slit positions enable pole to pole coverage. Full disk observations of Saturn (20″) can be obtained with one slit position.

Keck/NIRSPEC provides greater sensitivity than the others near IR spectrometers (e.g., IRTF/iSHELL). This results in shorter integration times and better background cancellation at M band. Spectroscopy of the Giant Planets in the thermal infrared (L and M bands, 3 to 5 μm) **requires excellent sky subtraction**. Improved background subtraction can be obtained by placing the end of the slit off-planet. In addition to the usual A-B sky subtraction (planet – sky), an average of several off-planet spatial pixels can be subtracted from each on-planet pixel. Strong telluric absorption lines of water, for example, frequently have negative counts before this correction and a correct value near zero after off-planet subtraction.

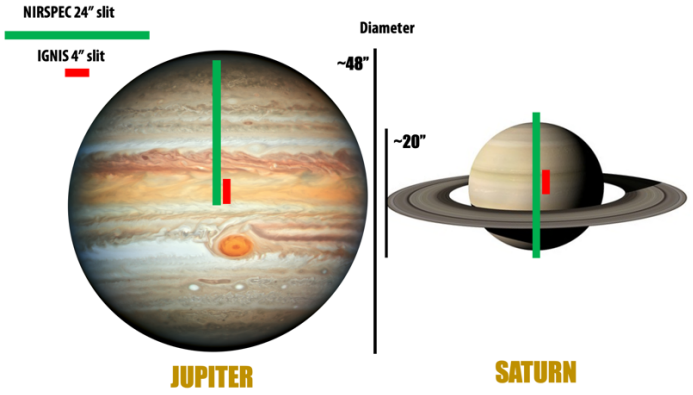

Figure 1. Long slit spectroscopy is a critical instrumentation capability that the Keck Observatory should maintain for the future.

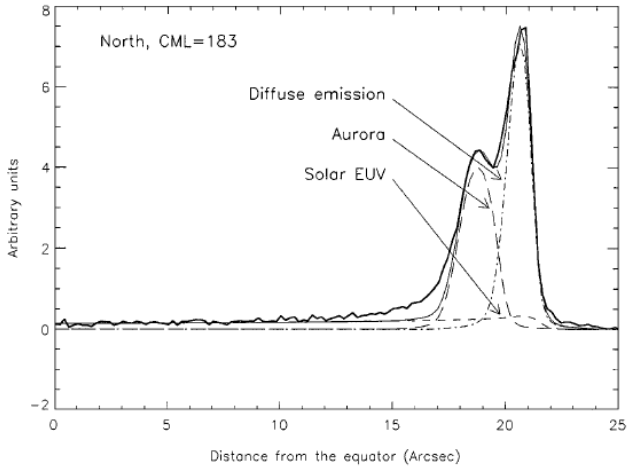

Figure 2. Latitudinal profiles of H_3^+ emissions in L-band, at 3.9 μm, of Jupiter's northen hemisphere. Aurora and diffuse emission peaks are shown in different dashed lines; they require a slit of at least 10" to be spatially distinguished and studied. (from Rego et al., 2000)

IGNIS has been proposed as a new high-resolution spectrometer for Keck. IGNIS provides the necessary wavelength coverage and spectral resolution, but its current design lacks the necessary slit length (currently designed to be 4″). With the adoption of a 4″ slit Jupiter's fast rotation would make mapping giant planets practically impossible, and therefore, making the **science of giant planets not feasible using Keck**.

In principle, one could map Jupiter from pole to pole using a 4″ slit in 12 steps. In practice, Jupiter's fast rotation would make this impractical.

In addition, slit positions away from the poles or away from the limb would not have the same quality of sky subtraction due to the lack of off-planet spatial pixels.

Thus, any new spectrometer being developed for Keck should include a long-slit capability for both L and M bands. This would allow us to continue to study the time variation of the atmospheres of the Giant Planets.

Why this critical instrumentation capabilities are competitive in 10 to 15-year timescales?

Ground-based long-slit high-resolution spectrometers in the 2.8–5 μm range (as NIRSPEC/ Keck) **will remain competitive** in the next 10-15 years. The mapping capability is essential when performing complementary observations with both spacecraft and Earth-based instrumentation of the Giant Planets. The combination of multi-band investigations allows a better understanding of the atmospheric dynamics and of the processes that shape Jupiter's atmosphere, as well as the complex interplay of winds, jets, and storms. Joint observations of space-based and ground-based observations have provided and will continue to promise an enriched level of science products.

D. Rego, S. Miller, and N. Achilleos, (2000) Icarus 147, 366–385. doi:10.1006/icar.2000.6444