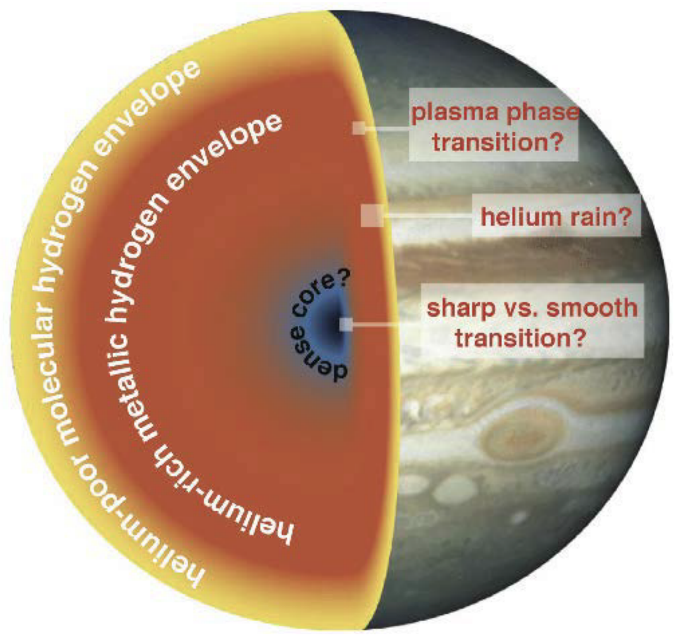
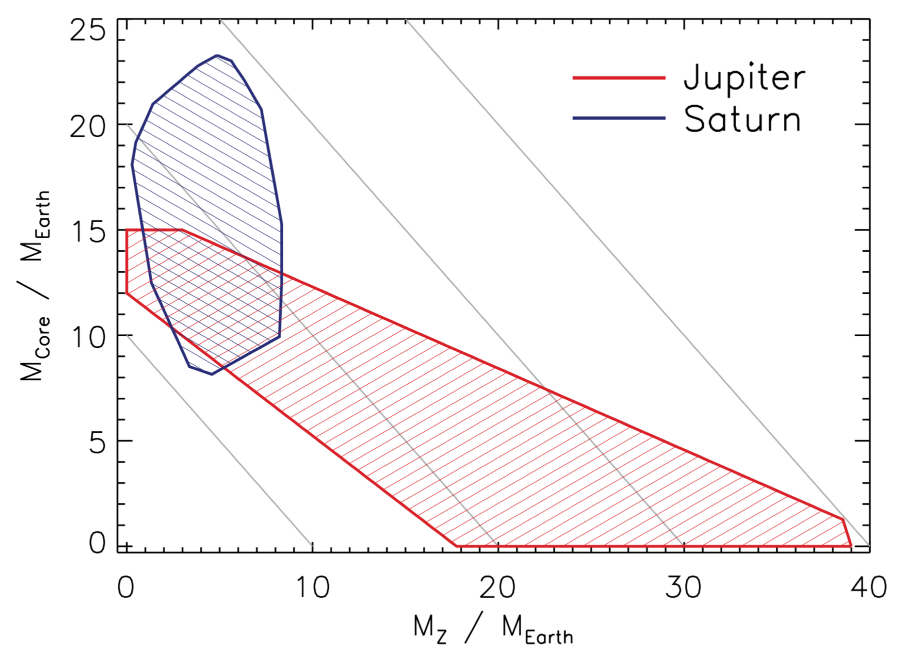
JIVE in NM: Jovian Interiors with Velocity Experiment in New Mexico

Primary Science Goal: how Jupiter and Saturn are structured?

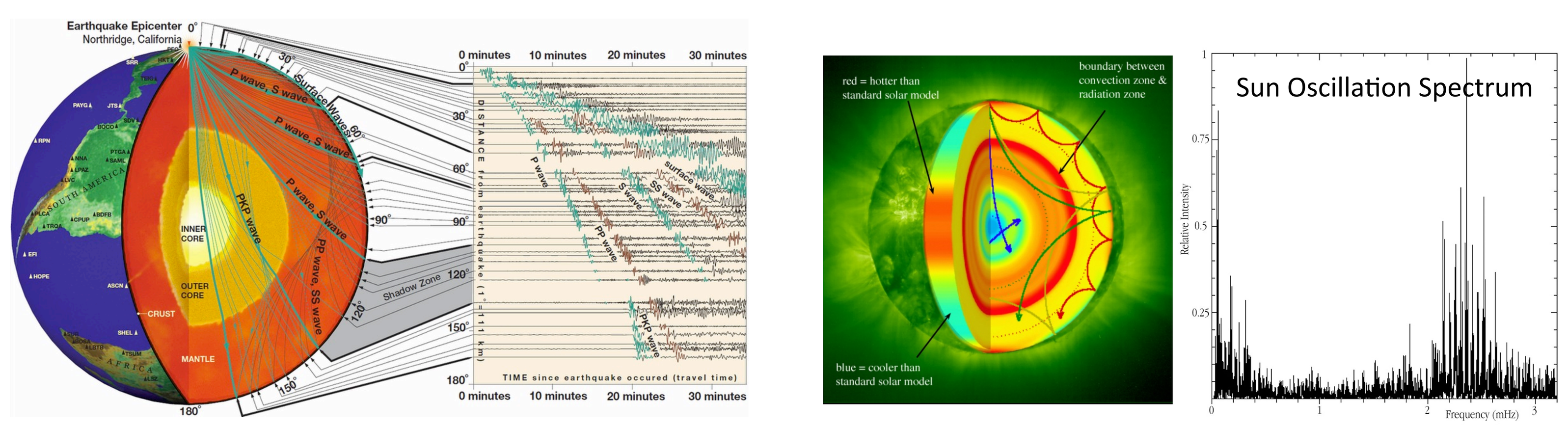




The range of Jupiter and Saturn core masses allowed by current theory. The core (M_{core}) and heavy element (M_Z) masses permitted by the gravitational harmonics and planetary rotation rates are shown. There is over a factor of two uncertainty in Saturn's core mass and only an upper limit (15 M_{Earth}) on Jupiter's core mass.

Method: seismology applied to giant planets

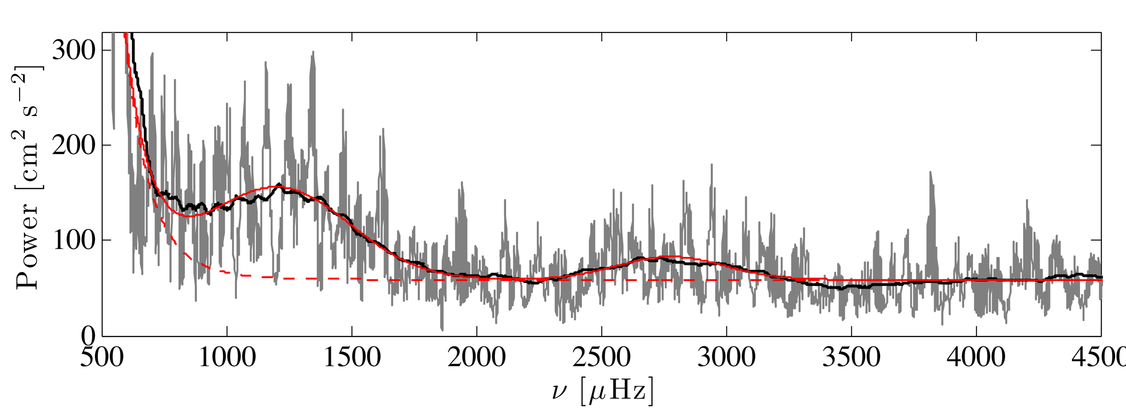
Seismology consists of retrieving properties of planetary/stellar internal structure by measuring frequencies of acoustic modes that resonate therein.



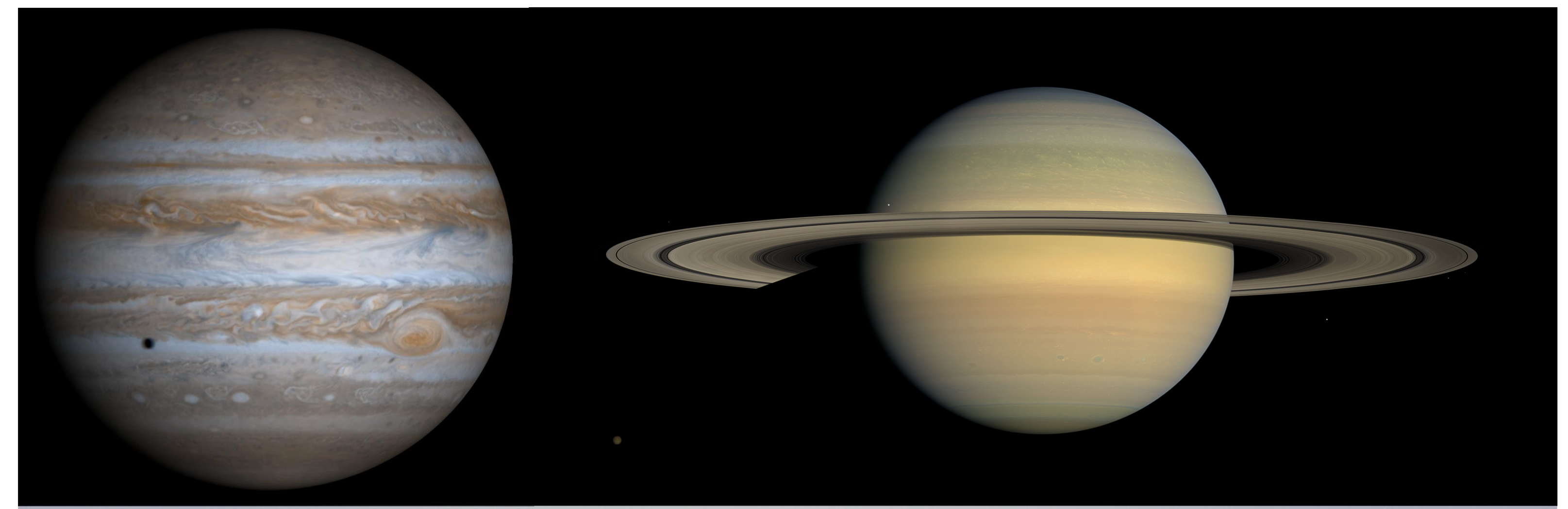
Giant planets are mostly fluid and convective, which makes their seismology much closer to that of solar-like stars than that of terrestrial planets. In other words, the cloudy "surface" of giant planets is slightly distorted by seismic acoustic waves that resonate therein. We aim at measuring these distortions.

Simulation of Jupiter distorted by acoustic oscillations with amplitude magnified by one million

So far, the two major results are a clear detection of acoustic oscillations of Jupiter (Gaulme et al. 2011), and the signature of Saturn inertial modes in the rings by the NASA Cassini spacecraft (Hedman & Nicholson 2013).



Above: evidence of the first detection of Jupiter's global modes from the SYMPA instrument, similar to the one to be built in this project. Excess oscillation power is detected between 800 and 3400 μHz, as well as a comb-like structure of regularly spaced peaks [from Gaulme et al. 2011].



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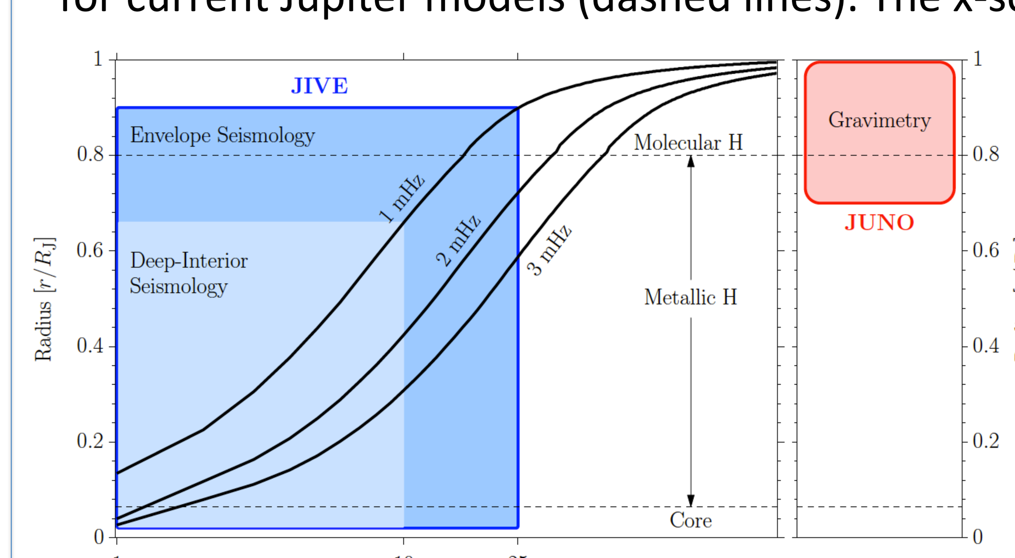
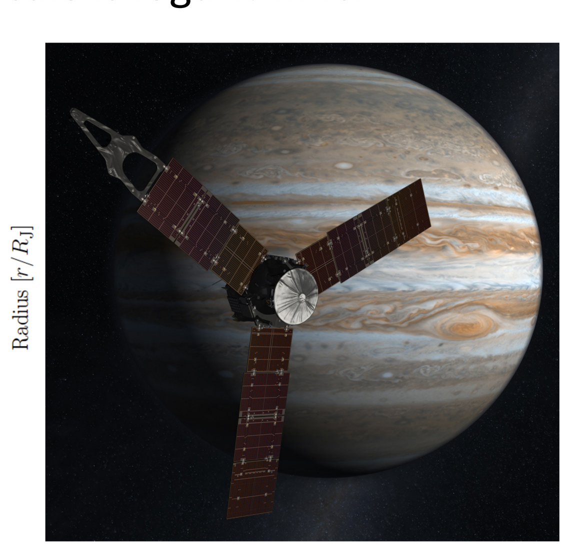
The Jovian Interiors from Velocimetry Experiment in New Mexico (JIVE in NM) project will address NASA's science goal of answering the question "How did the Sun's family of planets originate and evolve?" by determining the interior structure and composition of Jupiter and Saturn using seismology. A sensitive imaging spectrometer will be built in NM and installed on the NMSU 1-m telescope, located at Apache Point, that can measure the confirmed oscillations of these planets to a precision high enough to enable detailed studies of the planetary interiors. Since the gas-giant planets played such a critical role in the formation of the Solar System, and since so little about their core and compositional properties is constrained by observation, the seismic discoveries we will make with JIVE will finally allow us to discriminate between competing theories of planetary formation. Furthermore, precise measurements of the atmospheric winds will uncover new details into the physical processes that drive the zonal jets, and provide the data necessary to carry out monitoring of Jovian climatology to understand its complex dynamics.

This is a project of collaboration among undergraduate students, graduate students, faculty, and professional scientists and engineers geared towards ultimately solving fundamental questions in planetary science. Not only does it build upon the success of past NASA EPSCoR awards in the state, but establishes new expertise in advanced astronomical instrumentation and opens up an entirely new research direction for New Mexico that will last well beyond the three-year award period.

Complementarity with the NASA Juno Mission

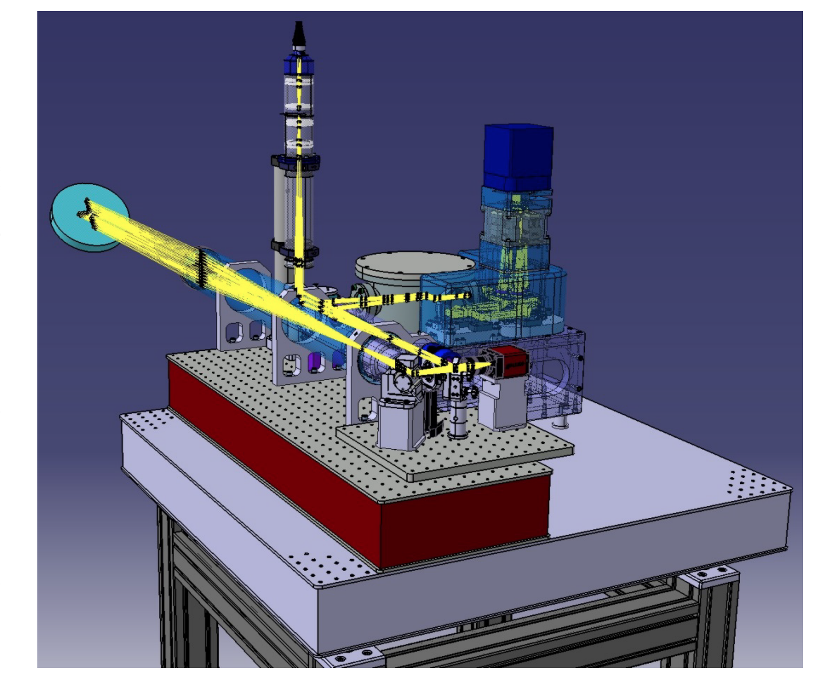
Jive and the NASA Juno mission are complementary. The blue box shows the interior range of Jupiter that will be possible to seismically explore with modes detected with Jive. This includes a deep-interior program (light blue) using low-degree modes, and an envelope program (darker blue) for higher-degree up to l = 25 when there is good telescope seeing. The red box shows the near-surface sensitivity possible from gravimetry with the Juno mission. Probe depths of a few example modes at the given frequencies and angular degree are shown (solid lines), as well as the expected transition locations for current Jupiter models (dashed lines). The x-scale is logarithmic.

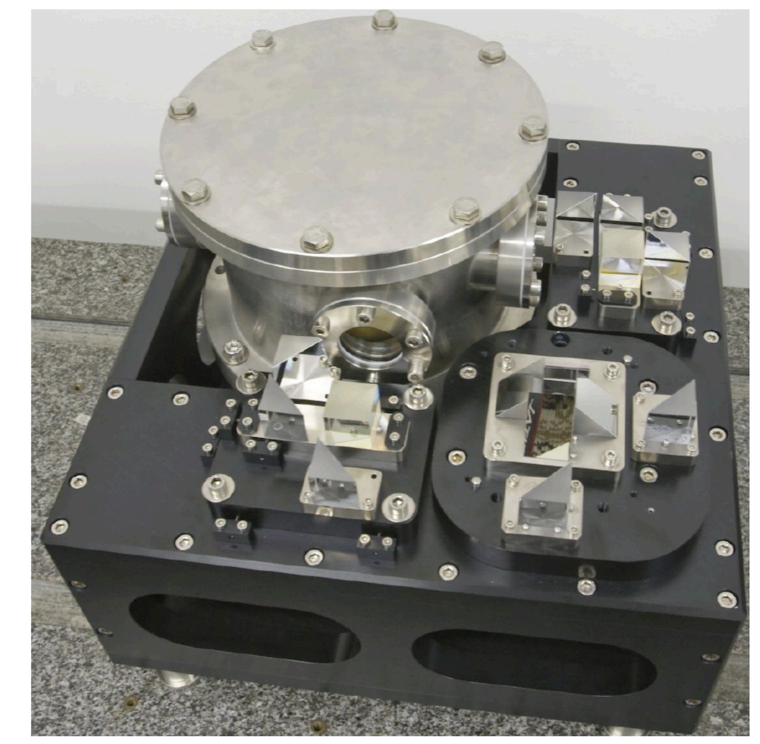


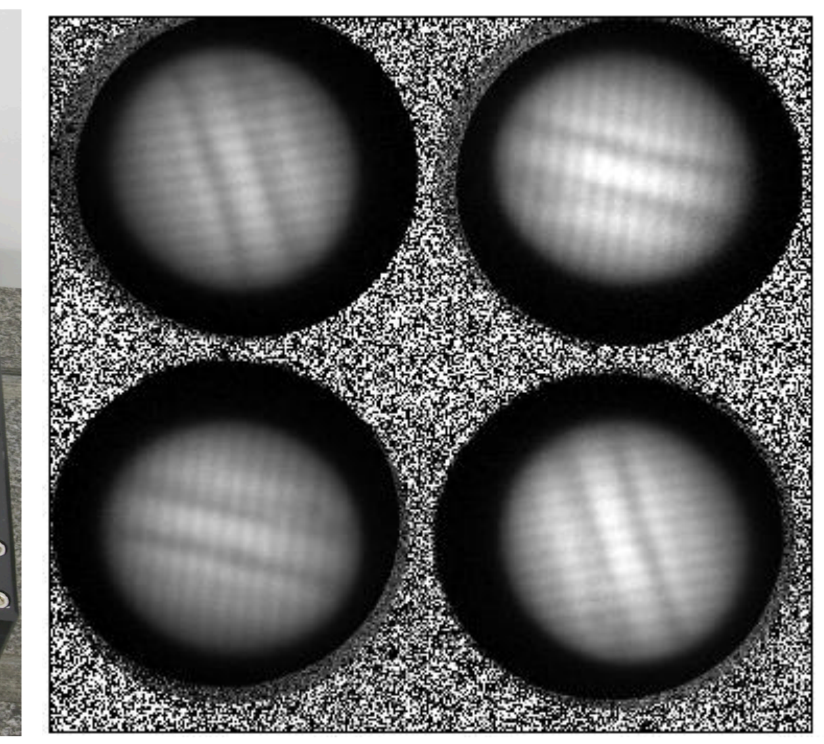


A solid base: a prototype developed and built in Nice, France

JIVE will measure the velocity of the cloudy "surface" of Jupiter, to look for tiny fluctuations due to the seismic oscillations. The instrument principle is based on high-resolution spectro-imaging in the visible domain. The optical design as well as a prototype weres developed in Nice in the frame of a study for a instrument to be placed on an ESA space-mission. It was successfully tested from the ground early 2014.

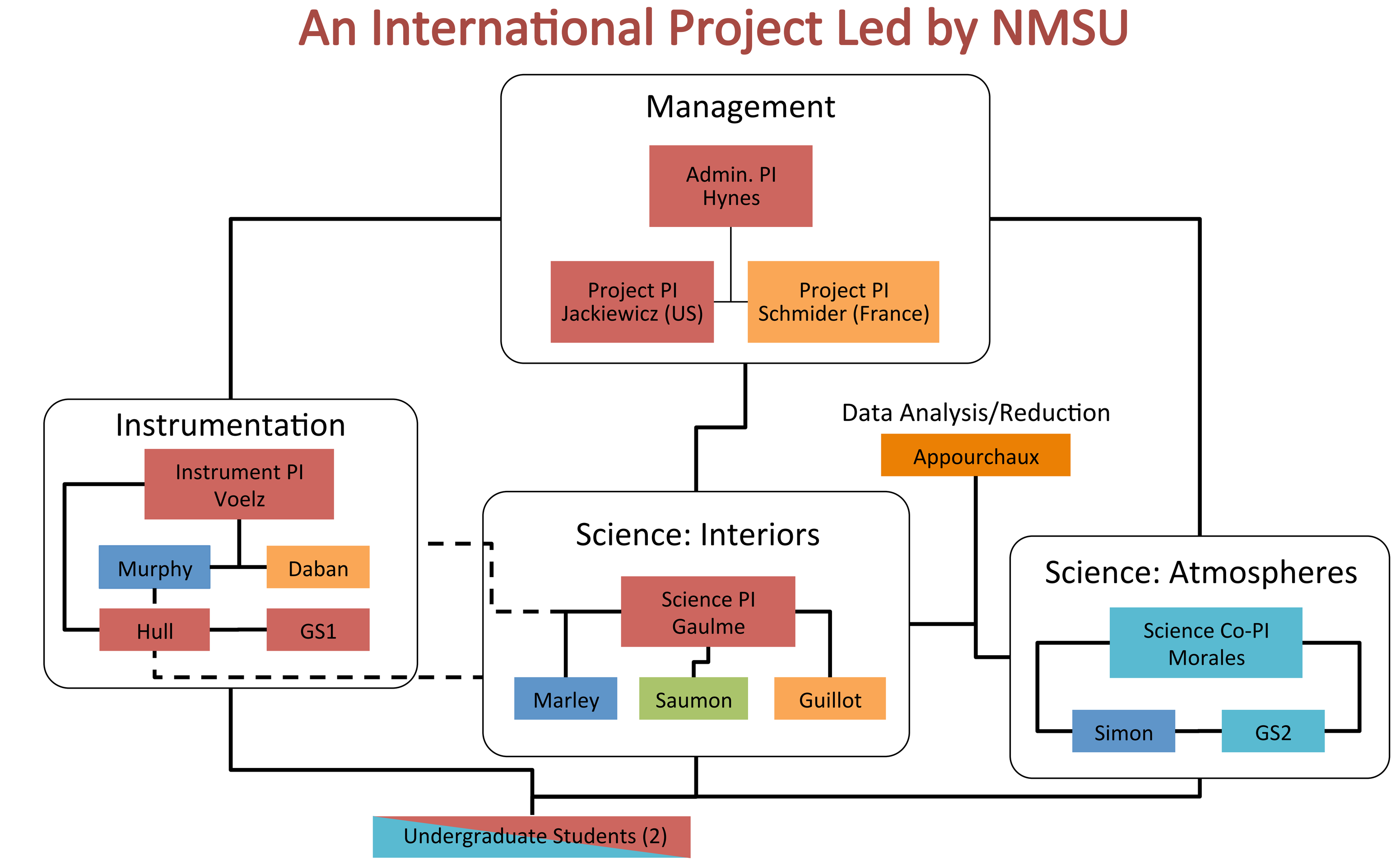






Prototype instrument and preliminary observations. The top panel shows the whole design of the instrument. The bottom left shows the components of the prototype corresponding to the interferometer. On the bottom right are the four output images of Jupiter used to compute velocity maps from the interferometric fringes (barely seen in this image rendering). The two main bands in each image at about 45 are zonal features of Jupiter's clouds.

An International Project Led by NMSU



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