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Centaurus: Exploring Centaurs and More, Messengers from the Era of Planet Formation

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Abstract

Centaurus is a non-nuclear Discovery mission proposed to make the first reconnaissance of Centaurs, escaped Kuiper Belt Objects (KBOs), via a series of flybys.

The fundamental goal of planetary science is to understand the origin and evolution of the solar system. The most powerful technique in planetary science is spacecraft exploration. Among the strongest lessons of that exploration is that missions to new types of bodies revolutionize knowledge of them and of how the solar system formed and evolved. *Centaurus* is a scientific mission of this type.

Centaurus has deep roots in both the 2003 and 2013 Decadal Surveys, addressing multiple Priority Questions and all three DS13 themes. *Centaurus'* targets include two scientifically amazing worlds: Chiron and Schwassman-Wachmann-1 (SW1); both are large Centaurs with evidence for rings and/or other dust structures above their surfaces and varying styles of coma activity. Crucially, the ~50 and ~220 km diameters of these Centaurs places them in the unexplored, almost two order of magnitude wide size gap between MU69 and Pluto. No such heliocentrically formed bodies have ever been explored, a significant limitation to understanding the origin and evolution of KB worlds and also planet and planetesimal formation in the outer solar system in general.

By exploring these Centaurs while also exploring other primitive bodies, *Centaurus* will reveal crucial new insights into planetesimal and dwarf planet formation as noted above, but also the evolution of such bodies, the source of distant cometary activity, the nature of rings around solid bodies, and will also contribute critical new inputs to understanding Kuiper Belt formation.

Centaur Targets

The Kuiper Belt consists of myriad well-preserved planetesimals (i.e., intermediate-sized bodies up to 100s of km in diameter) and a population of larger objects called dwarf planets. Centaurs are escapees from the Kuiper Belt's Scattered Disk [2]—an ancient, unexplored KBO population of less evolved objects than Pluto, and with different origins [3] than the Cold Classical KBO 2014 MU_{69} that New Horizons explored. But unlike Scattered Disk bodies, which orbit beyond Neptune, Centaurs are more accessible, temporarily (i.e., 10^{5-7} yr) orbiting far closer, among the giant planets [e.g, 2, 4].

Among the *Centaurus* targets, SW1 has the most persistent and active coma of any known Centaur [e.g., 5]; it also displays one (and sometimes more) large coma dust structures [6-8]. It's size, some 5-60 km in diameter, suggests it is an order of magnitude more massive than 2014 MU_{69}, which New Horizons explored.

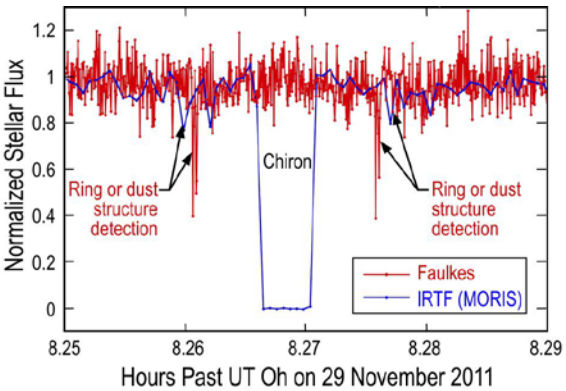

Figure 1: Chiron has displayed evidence for orbiting rings or other dust structures in multiple stellar occultations. Here is a 2011 stellar occultation showing evidence of symmetric, hence likely ring, opacity structures with significant optical depths (modified from [1]).

Chiron's attributes are even more impressive: it is the second largest Centaur, ~2000× as voluminous (and presumably about as much more massive) as MU69, and also frequently shows a coma [9-12]. Further, stellar occultations have shown that Chiron also hosts dense orbiting rings or dust structures [1, 13-15]. No mission has explored these puzzling phenomena around any body.

Summary

The core of the *Centaurus* Discovery mission is the inaugural exploration of Centaurs. By exploring these KBO ejectees now at closer range, *Centaurus* becomes the next chapter in KBO exploration—and expands the types of explored KBOs (resonant and cold classicals) to include Scattered Disk Objects. *Centaurus thus* accomplishes KBO exploration on a Discovery budget and without the need to use precious nuclear resources for the next stage in KB exploration. *Centaurus* carries a payload of imagers and spectrometers to study the surfaces and atmospheres/comae of its flyby targets, and can launch in any year from 2026 to 2029. *Centaurus* is a joint SwRI-JPL proposal; Lockheed-Martin is the spacecraft provider.

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