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Argo: Exploring the Neptune System and Beyond

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Abstract

Exploration of the local ice giant Neptune has been stymied by a perception that an orbiter (i.e., a Galileo- or Cassini-like flagship mission) is required for major scientific progress. We assert that advances in our understanding of these systems (atmospheres, rings, and moons)—as well as our understanding of the populace of the Kuiper Belt—have changed dramatically since Voyager (Fig. 1), thus a simple spacecraft equipped with modern technology will yield significant new ice-giant system science. We describe a mission that flies by the Neptune system and continues on to explore a Kuiper Belt object (KBO).

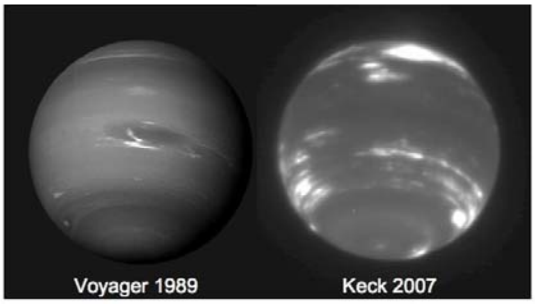

Figure 1: Neptune then and now. Nearly all aspects of the Neptune system have evolved considerably in the decades since the Voyager flyby, as have the technologies available to flight missions. Although the Voyager image is at visible wavelengths and the Keck image is in the near IR, visible HST images reveal the changes are intrinsic, not due to wavelength [1,2].

Scientific Motivation

Recent and ongoing space programs exist for terrestrial planets (Earth, Mars, Venus) and for gas giants (Jupiter, Saturn), but not for the intermediate-sized planets. Yet these ice giants, along with gas giants, were key players in the evolution of our circumstellar disk. The formation of Uranus and Neptune, and in particular their subsequent migration to their present locations, dynamically sculpted the distribution of the nascent Kuiper Belt.

Clues to ice giant formation and evolution, hidden in their chemistry and in the chemistry and evolutionary history of Triton and other ice-giant satellites, will provide inputs for studies of extrasolar planetary disk evolution. The Neptune system thus yields rich scientific return in a broad sense, in addition to detailed knowledge of the intrinsic Neptune environment itself.

Exploration Opportunities

Some aspects of the Neptune system were not probed at all by Voyager and/or cannot be observed from Earth, e.g., Triton's northern hemisphere; smaller moons; detailed structure within the ring system; and Neptune’s interior and magnetic field. Furthermore, a flyby mission gives us the opportunity to go on to a KBO, and the trajectory bending angle from the mass of Neptune opens up a large cone of space thus numerous potential KBO targets. We list below just a few of the measurement objectives accessible to a Neptune flyby, but impossible from L2, from near-Earth orbit, and from Earth even with a 30-m telescope.

Neptune

Discovery opportunities for a Neptune flyby include: detection of small-scale cloud distribution and its relationship to large-scale structure seen from Earth; high phase-angle coverage of the atmosphere; detection of atmospheric lightning; magnetic field measurements; first detailed infrared map; and refined gravitational moments

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for interior models. A months-long approach-phase movie will produce major advances in dynamical studies.

Triton

Discovery opportunities for a Triton flyby include: significantly improved geologic map; detection of surface ice evolution, volatile migration, and atmospheric structure changes; detection of a magnetic field; and the first detailed infrared map of Triton.

Ring system

Discovery opportunities during a Neptune system flyby include images, as well as high phase-angle coverage, of the detailed structure and evolution of Neptune's unique arc-dominated rings.

Nereid and other small moons

Discovery opportunities during a Neptune system flyby include the first detailed images and high-phase angle coverage of these distant tiny bodies.

Kuiper Belt Objects

Discovery opportunities for a KBO fly-by include: a geologic map; determination of the surface ice distribution; detection of surface and atmospheric structure; detection of a magnetic field; and a detailed infrared map.

Summary

Neptune and its moon Triton are compelling flyby targets. They are both dynamic worlds, rich in opportunities for new science discoveries. We have identified trajectories with reasonably short trip times and low approach velocities. *A post-Neptune KBO encounter permits a rich suite of outer-solar-system comparative planetology.* Neptune's mass enables numerous potential KBO targets for a subsequent flyby. When combined with New Horizons exploration of Pluto and a KBO, this mission's study of Triton and a different KBO will double the number of small outer Solar System bodies to be studied in detail by spacecraft. Key science can be addressed by an instrument package based on New Horizons heritage.

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References

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