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The unique but critical science of the outer planets possible only with entry probes

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Conventional models of the formation of the giant planets require formation of a substantial core -presumably of rock, metal and ice - initially, followed by gravitational capture of the most volatile of the gases, hydrogen, helium and neon, leading up to the collapse of the surrounding protoplanetary nebula. The atmosphere resulted from these last gases and the gases released from the core material during the accretionary heating phase and subsequent thermochemistry in the planets' interior. The core could make up 3-5% of the planetary mass at Jupiter, as much as 10% at Saturn and 90% at Uranus and Neptune. Moreover, oxygen in the form of water may contribute between one-half and two-thirds of the core mass in the case of Jupiter and Saturn. The other heavy elements (mass greater than helium) would comprise the rest. The measurement of the heavy elements is thus key to the question of the formation of the gas giant planets as well as the ice giant planets, irrespective of the details of their formation process including possible migration. Remote sensing does not permit access to the most critical heavy elements, except for carbon (from CH4). The bulk composition, particularly the elemental abundances of N, S, and O, heavy noble gases (Ne, Ar, Kr and Xe), He (for interior processes), isotopes of noble gases, and 14N/15N, D/H, 3He/4/He, require entry probes. In this talk, we will also recommend for each giant planet the set of baseline measurements, together with a strategy to realize them within the medium (NASA/New Frontiers, ESA/Cosmic Vision-M) and higher cost missions.