DO JUNO MWR RESULTS INVALIDATE GALILEO PROBE NOBLE GAS AND ISOTOPE MEASUREMENTS?

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Introduction: The Galileo Probe Mass Spectrometer (GPMS) [1] provided the only existing noble gas abundance and isotope ratio measurements in a giant planet atmosphere (see Fig. 1) [2]. Additionally, GPMS provided a level of precision for $^{14}N/^{15}N$ that could not be achieved with current remote sensing technology [3]. These measurements provide groundbreaking information for decoding the origin and evolution of the giant planets [4,5], and by extension the history of the solar system. As such, they have been identified in the most recent Planetary Science and Astrobiology Decadal Survey as Supportive Activities needed to answer several Priority Questions [6].

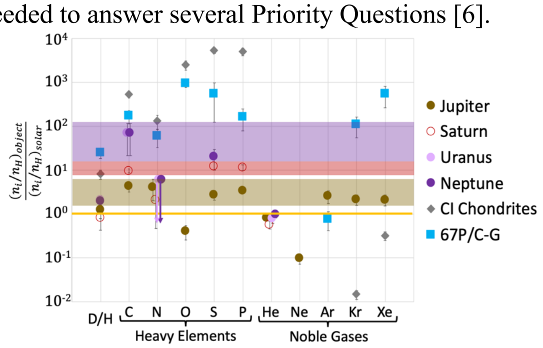

Figure 1 – Noble gas and heavy element abundances relative to solar values for the solar system giant planets and analogs for building block materials [from 4].

Impact of Galileo Probe to State of Knowledge: Jupiter's noble gas abundances provide constraints on Jupiter's formation conditions and building blocks [e.g. 4,5,7,8]. However, fundamental questions remain about whether Jupiter formed from comets that have solar heavy element composition [7], which is not supported by Rosetta noble gas abundance measurements in comet 67P (Fig. 1) [4], or if it formed from supersolar gas [8]. Noble gas measurements from the other giant planets are critical for resolving how the giant planets formed and if they migrated after formation [4,5].

The $^{14}N/^{15}N$ measured by GPMS was the first protosolar value observation [9]. This measurement provides a benchmark for studying the origin of nitrogen on Earth and other solar system bodies [e.g. 10,11]. No measurements are available for Uranus or Neptune, and only an upper limit for Saturn [12].

Juno MWR Results: The Juno Microwave Radiometer (MWR) [13] provided the first global map of ammonia for a giant planet down to ~100 bar [14]. These measurements show an ammonia depletion at levels deeper than where ammonia is expected to be well mixed (see Fig. 2). Two mechanisms are proposed to explain this depletion: the formation of mushballs that adsorb and remove ammonia [15] and a stacked system of meridional cells [16]. We note that although GPMS did not reach the well-mixed layer for ammonia, the measured nitrogen abundance [3] is greater than that inferred from Juno MWR [14], suggesting that GPMS measured a well-mixed upwelling unresolved by Juno.

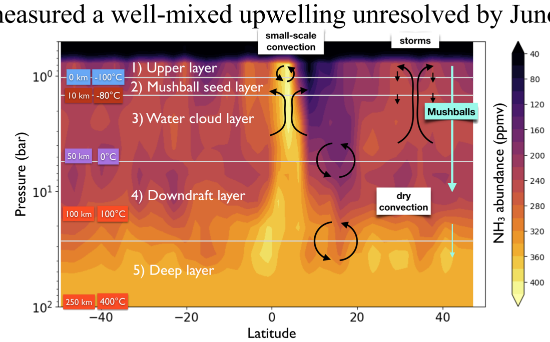

Figure 2 – Juno MWR average ammonia abundance in Jupiter's atmosphere showing layers and mechanisms used in the simple mass and energy balance model for the mushball theory [from 15].

Fundamental Questions: Noble gas and nitrogen isotope ratio measurements from Saturn will provide critical information on how gas giants formed. Additionally, comparing GPMS measurements to noble gas abundances and isotope ratios in Uranus and Neptune are critical for understanding formation and evolution of ice giants compared to gas giants [4,5]. We will discuss whether Juno MWR results impact the GPMS noble gases and isotope ratios and the reliability of atmospheric probes, which are the only method for obtaining these critical observations.

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