National Aeronautics and Space Administration

Tracing Water from Interstellar Clouds to Ocean Worlds

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Program: FY21 R&TD **Strategic Focus Area: Tracing Water from Interstellar Clouds to Ocean Worlds**

Objectives

This initiative studies the connection between chemical processes in the interstellar medium and critical aspects of habitable planet formation. A particularly important aspect is tracing the trail of water, from its interstellar reservoir to planet forming disks, and to primitive Solar System bodies, such as comets, as it brings important insights in understanding how the primitive Earth obtained its water.

Background

Figure 1 illustrates schematically some of the key steps that we want to understand to appreciate how water formed in the interstellar medium ends up on habitable planets such as the Earth. A key discriminant are isotopic ratios, in particular the D/H ratio in water found in comets compared to that on the Earth. Figure 2 summarizes results in meteorites and comets, obtained from ground-based and space platforms. Measurements of a statistically significant sample of comets are required to give a definitive answer, and a dedicated space mission to study isotopic ratios in water is the only way to provide such meaningful statistical results..

Approach and Results

We have carried out a detailed study of a MIDEX mission concept, *Source*, aimed at understanding how the conditions of habitability develop during the process of planet formation. *Source* is a passively cooled 3-m class FIR telescope with an SIS heterodyne instrument that would cover the 460-530 GHz and 530-610 GHz frequency bands simultaneously, with 2 pixels in each frequency band. Source will have sufficient sensitivity to measure the D/H ratio in a significant statistical sample of Solar System comets, protoplanetary disks, prestellar cores and molecular clouds. The concept could be re-scoped as a Probe mission, adding a direct detection instrument covering the wavelength range 25 - 200 μm with spectral resolution 10,000 for observations of the 47 μm pristine water ice band, as well the 112 μm HD line in disks, to measure disk mass.

Significance/Benefits to JPL and NASA

Past and ongoing observations together with the technical work carried out here guides development of new mission concepts for FIR spectroscopy. Although the *Source* concept was deemed too expensive for MIDEX, in falls well under the Discovery and Probe cost caps.

Publications

21 refereed publications since the start of the SRTD: see ADS

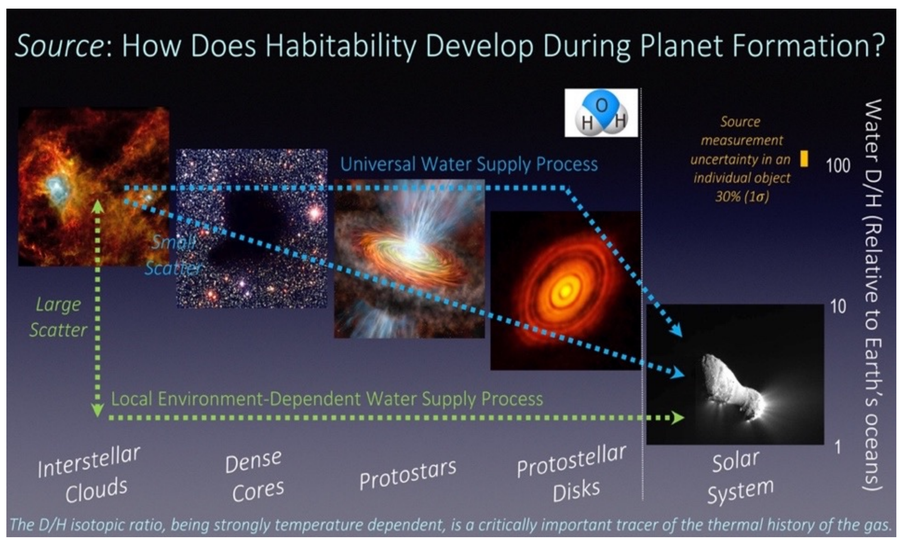

Figure 1. Schematic of the phases of the water trail from the Source mission concept.

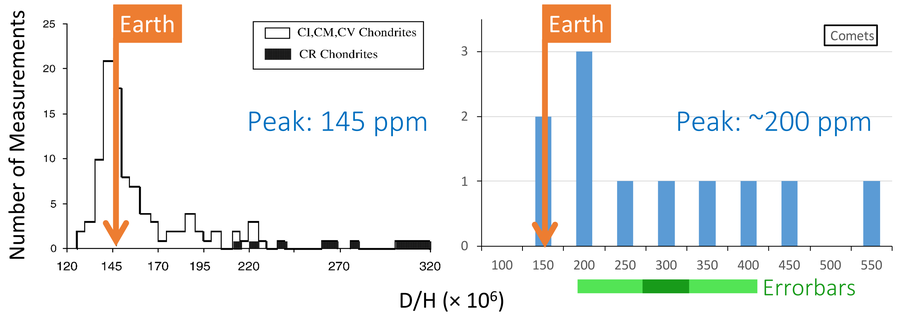

Figure 2. Distribution of the D/H ratio in meteorites (Left) and comets (Right). Only a dozen of measurements exist in comets.

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Poster No. R18011
Clearance No.21-4341
JPLTask#R18011