Noble gases from the interstellar medium trapped on the MIR space station and analyzed by in vacuo etching

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Noble Gases from the Interstellar Medium Trapped on the Mir Space Station and Analyzed by In Vacuum Etching.


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Introduction: The composition of the present interstellar medium (ISM) provides an important benchmark in cosmochemistry. It serves as a reference for galactic chemical evolution (GCE) models, solar mixing predictions and provides information for understanding Big Bang nucleosynthesis. The present-day ISM 3He abundance allows, combined with the protosolar 3He, deduced from the Jovian atmosphere or meteorites [1,2], tracing the GCE over the past 4.56 Ga. 3He/4He = (2.5±0.6) x 10^{-4} has been determined for the local ISM [3]. However, the uncertainty is too large to better constrain GCE models and - in combination with the present-day solar wind value - the protosolar D/H [4].

Experiment: The COLLISA experiment [Collection of Interstellar Atoms, 5,6] sampled interstellar gas in Cu-Be foils covered with BeO and exposed to the flux of neutrals from the ISM on board the MIR space station. Stepwise heating extraction allowed the detection of interstellar 4He [6] and yielded (3He/4He)ISM = (1.7±0.8) x 10^{-4} [7], in agreement with the value for pickup ions observed with SWICS/Ulysses [3].

Further foils are currently analyzed by closed system stepwise etching at ETH Zurich [8]. This technique allows to efficiently separate implanted interstellar He and terrestrial tritiogenic 3He, probably residing in the Cu-Be substrate, which had to be taken into account for the determination of interstellar 3He during stepwise heating [7].

Results: Offline tests suggest that HF acid vapor efficiently and uniformly etches BeO. The system blank (in 10^{-14} cm^{3} STP, 3He ~3, 4He ~300, 20Ne ~90) is now sufficiently low to measure the exposed foils. Two unexposed foils (31 and 50 cm^{2}) were etched online and yielded no significantly increased values relative to these blanks, implying that the tritiogenic 3He (0.5-1 10^{-14} cm^{3/cm^{2}} foil) indeed resides in deeper foil layers that are not affected by superficial etching. The analysis of a foil artificially irradiated with 3He and 20Ne at energies comparable to those of the ISM neutrals (25 eV/amu) showed that our protocol (10 steps 1-30 min, HF vapor at 20 °C) releases all trapped noble gases. Results of the ongoing etching experiment on foils exposed to the ISM (including a witness foil doped with terrestrial 3He) will be presented. The expected concentrations of interstellar gas [3,6,7] in 50 cm^{2} of exposed foil are (in 10^{-14} cm^{3} STP) 3He ~25, 4He ~20000, 20Ne ~200000.

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