THE ISOTOPIC COMPOSITION OF INTERSTELLAR HELIUM MEASURED BY IN-VACUO ETCHING OF A METAL FOIL EXPOSED ON THE MIR SPACE STATION

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Introduction: Among the few successful sample return missions, the Swiss-Russian COLLISA (Collection of Interstellar Atoms) collaboration [1,2] has received relatively little attention. Here we discuss the isotopic composition of interstellar neutral He trapped on a CuBe foil exposed on the MIR Space station, obtained by stepped in vacuo etching of the thin BeO surface layer of the foil and online mass spectrometric analyses [3].

Trapping and analysis techniques: 50 cm^2 of foil exposed during some 60 h to the flux of interstellar neutral atoms impinging with a velocity of >60 km/s (corresponding to an implantation depth in BeO of some 2-3 nm) were analysed in ten steps of etching by HF, five of which yielded both ^3He and ^4He above detection limits [3]. This technique resulted in much lower blanks than stepwise heating extractions [2], since only the BeO layer was dissolved. Tritiogenic ^3He in the bulk foil [2] did thus hardly compromise the etching data.

Results and Discussion: Summing ^3He and ^4He of the gas-rich steps and correcting for blanks yields a $^3He/^4He$ ratio of $1.18*10^{-4}$. Corrected for the variable trapping efficiency of the two He isotopes, this yields a $^3He/^4He$ ratio for the Local Interstellar Medium (LIC) of $(1.62 \pm 0.29)*10^{-4}$. This is the most precise value for interstellar He obtained so far, but an earlier value obtained on another MIR foil piece [2] and a ratio measured in situ with pick-up ions [4] both agree with our value within their larger uncertainties. The main source of uncertainty of our value is the correction for variable trapping efficiency of ^3He and ^4He while the uncertainty of the ratio deduced by [4] was governed by ion counting statistics.

The ^3He abundance relative to ^4He in the LIC is very close to the value of $1.66*10^{-4}$ inferred for the protosolar cloud [cf. 3], showing that no significant increase of ^3He took place since solar system formation. In contrast, a small but notable increase of ^3He relative to its primordial value 13.7 Ga ago of $\leq(1.1\pm0.2)*10^{-4}$ [5, cf. 3] occurred up to solar system formation. This observation sets constraints on galactic chemical evolution models. As predicted by standard stellar models [6], some stars should be net producers of ^3He, but much of this ^3He may be destroyed again due to "extra mixing" [7]. Our data show that indeed most, though not all, low-mass stars undergo such extra mixing. At a distance of ~8kpc from the center of the Galaxy, the ^3He abundance has not substantially changed since about 4.56 Ga ago.

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