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A very reduced upper limit on the interstellar abundance of beryllium[1]

Guillaume Hébrard

Institut d'Astrophysique de Paris, CNRS, 98 bis boulevard Arago,
F-75014 Paris, France

Martin Lemoine

DARC, Observatoire de Paris-Meudon, France

Roger Ferlet and Alfred Vidal-Madjar

Institut d'Astrophysique de Paris, France

Abstract. We present the results of observations of the $\lambda3130$Å interstellar absorption doublet of ^{9}Be II in the direction of ζ Per. The data were obtained at the Canada-France-Hawaii 3.6m telescope using the Gecko spectrograph at a resolving power ~ 110 000 and a signal-to-noise ratio ~ 2000. The ^{9}Be II lines are not detected and we obtain an upper limit on the equivalent width $W \leq 30\mu$Å. This upper limit is 7 times below the lowest upper limit ever reported hitherto. The derived interstellar abundance is $(^9\mathrm{Be/H}) \leq 7 \times 10^{-13}$; it corresponds to an upper limit $\delta_{Be} \leq -1.5$ dex on the depletion factor of ^{9}Be.

1. Introduction

Beryllium is created in Big Bang nucleosynthesis with an extremely low primordial abundance. Subsequently, it is solely formed in spallation reactions of galactic cosmic rays (GCR) interacting with interstellar atoms, and is thoroughly destroyed through astration of interstellar gas. This simple scenario allows to account for the observed Pop I abundance of ^{9}Be, $(^9\mathrm{Be/H})_{PopI} \simeq 1.3 \times 10^{-11}$ (Boesgaard 1976), the solar abundance $(^9\mathrm{Be/H})_\odot \simeq 1.4 \times 10^{-11}$ (Chmielewski et al. 1975) and the meteoritic abundance $(^9\mathrm{Be/H})_{met} \simeq 2.6 \times 10^{-11}$ (Anders & Grevesse 1989). For this reason, ^{9}Be together with ^{6}Li, which shares a similar evolutionary picture, are used as tracers of cosmic ray spallation activity.

From ground observatories, beryllium can only be observed through the resonance ^{9}Be II doublet at 3130Å. It has never been detected in the ISM [see Hébrard et al. (1997) for a review of reported upper limits]. Beryllium depletion factor, largely unknown, is predicted to be ~ −0.2 dex in a correlation with first ionization potential, and ~ −1.5 dex in a correlation with condensation temperature (Boesgaard 1985).

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[1] Based on observations collected at the Canada-France-Hawaii Telescope, Hawaii, USA.

We report here on our observations of the interstellar absorption of ^{9}Be II in the direction of ζ Per. Further details can be found in Hébrard et al. (1997).

2. Observation and result

Our observations were conducted in January 1994 and October 1995 at the Canada-France-Hawaii 3.6m telescope. We used the spectrograph Coudé f/4 Gecko at high resolving power $\lambda/\Delta\lambda \simeq 110\,000$. We reach a signal-to-noise ratio of ~ 2000 per pixel in the vicinity of the expected line, for a total integration time of 25h. The ^{9}Be II doublet was not detected on our spectra.

The absence of detection at such a high signal-to-noise ratio and resolution translates into a very reduced upper limit on the beryllium column density. Indeed, the limiting detectable equivalent width at 3 σ is $W_{lim} \simeq 30\,\mu$Å, implying the upper limit on the column density $N(^9\mathrm{Be\,II}) \leq 1.0 \times 10^9$ cm^{-2}.

We assume now that at least 90% of the interstellar beryllium is present in the first ionization stage ^{9}Be II (Boesgaard 1985). This is supported by the ratios between ionization stages of others elements. For example, in this same line of sight, $N(\mathrm{Mg\,I})/N(\mathrm{Mg\,II}) \leq 10^{-2}$ and $N(\mathrm{S\,III})/N(\mathrm{S\,II}) \leq 10^{-3}$ (Snow 1977). Taking the hydrogen column density toward ζ Per $N(\mathrm{H}) = 1.6 \times 10^{21}$ cm^{-2} (Savage et al. 1977), we thus deduce an upper limit of the interstellar abundance for ^{9}Be toward ζ Per: $(^9\mathrm{Be/H})_{\zeta\,Per} \leq 7 \times 10^{-13}$.

3. Conclusion

Our interstellar abundance of ^{9}Be is at least 35 times less than the cosmic abundance, $(^9\mathrm{Be/H})_{cosm} \simeq 2.6 \times 10^{-11}$. It corresponds to a depletion factor $\delta_{Be} \leq -1.5$ dex. This is a new and much more stringent upper limit compared to previous ones ($\delta_{Be} \leq -0.4$, Boesgaard 1985).

Our present upper limit favours the Field (1974) model of dust grain formation in stellar material. In effect, the predicted depletion for the condensation temperature of ^{9}Be is ~ -1.5 dex while the Snow (1975) model of dust grain formation by chemical trapping predicts $\delta_{Be} \simeq -0.2$ dex.

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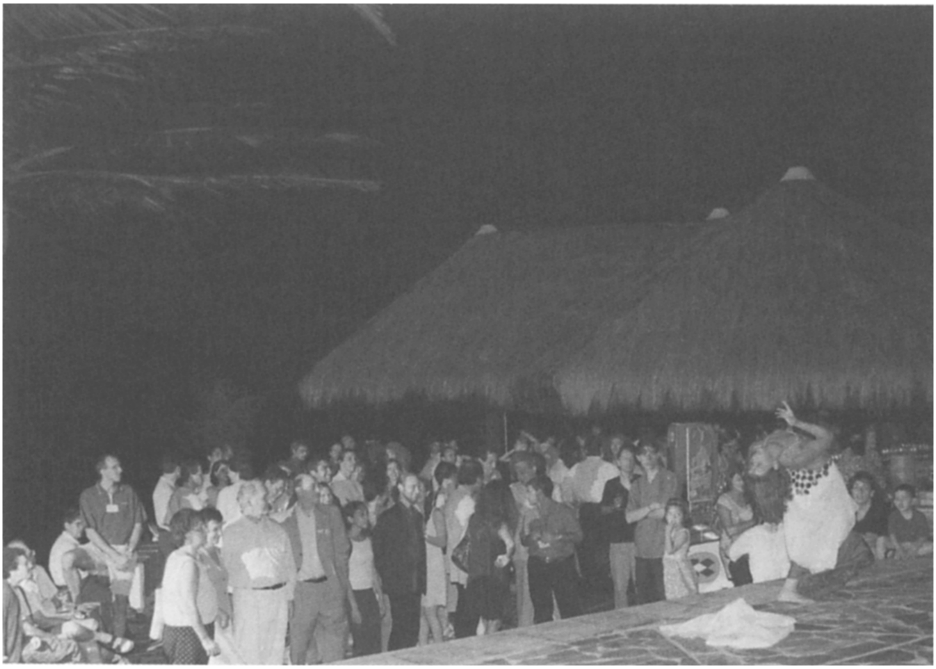

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