Lithium burning

Lithium burning is a nucleosynthetic process in which lithium is depleted in a star. Lithium is generally present in brown dwarfs and not in low-mass stars. Stars, which by definition must achieve the high temperature (2.5×10^6 K) necessary for fusing hydrogen, rapidly deplete their lithium.

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^{7}Li

Burning of the most abundant isotope of lithium, lithium-7, occurs by a collision of ^{7}Li and a proton producing two helium-4 nuclei. The temperature necessary for this reaction is just below the temperature necessary for hydrogen fusion. Convection in low-mass stars ensures that lithium in the whole volume of the star is depleted. Therefore, the presence of the lithium line in a candidate brown dwarf's spectrum is a strong indicator that it is indeed substellar.

^{6}Li

From a study of lithium abundances in 53 T Tauri stars, it has been found that lithium depletion varies strongly with size, suggesting that lithium burning by the P-P chain, during the last highly convective and unstable stages during the pre–main sequence later phase of the Hayashi contraction may be one of the main sources of energy for T Tauri stars. Rapid rotation tends to improve mixing and increase the transport of lithium into deeper layers where it is destroyed. T Tauri stars generally increase their rotation rates as they age, through contraction and spin-up, as they conserve angular momentum. This causes an increased rate of lithium loss with age. Lithium burning will also increase with higher temperatures and mass, and will last for at most a little over 100 million years.

The P-P chain for lithium burning is as follows

$$
\begin{aligned}
p + {}^{6}_{3}\mathrm{Li} &\rightarrow {}^{7}_{4}\mathrm{Be} && \text{(unstable)} \\
{}^{7}_{4}\mathrm{Be} + e^{-} &\rightarrow {}^{7}_{3}\mathrm{Li} + \nu \\
p + {}^{7}_{3}\mathrm{Li} &\rightarrow {}^{8}_{4}\mathrm{Be} && \text{(unstable)} \\
{}^{8}_{4}\mathrm{Be} &\rightarrow 2\,{}^{4}_{2}\mathrm{He} + \text{energy}
\end{aligned}
$$

It will not occur in stars less than sixty times the mass of Jupiter. In this way, the rate of lithium depletion can be used to calculate the age of the star.

Lithium test

The use of lithium to distinguish candidate brown dwarfs from low-mass stars is commonly referred to as the **lithium test**. Heavier stars like our Sun can retain lithium in their outer atmospheres, which never get hot enough for lithium depletion, but those are distinguishable from brown dwarfs by their size. Brown dwarfs at the high end of their mass range (60–75 M_J) can be hot enough to deplete their lithium when they are young. Dwarfs of mass greater than 65 M_J can burn off their lithium by the time they are half a billion years old; thus, this test is not perfect.[1]

See also

- Cosmological lithium problem

References

1. Basri, G. (1998). Rafael Rebolo; Eduardo L. Martin; Maria Rosa Zapatero Osorio (eds.). *The Lithium Test for Young Brown Dwarfs (invited review)* (http://articles.adsabs.harvard.edu//full/1998ASPC..134..394B/0000399.000.html). *Proceedings of a Workshop held in Puerto de la Cruz, Tenerife, Spain, 17–21 March 1997, ASP Conference Series #134*. p. 394. Bibcode:1998ASPC..134..394B (http://adsabs.harvard.edu/abs/1998ASPC..134..394B).