Laser techniques to measure the opacity under these conditions are just now being developed. However, high pressure shock wave techniques for measuring the equation of state are well established. Comparison of the extended OPAL equation of state with shock data will be shown.

58.05

Some Surprises Concerning the Origin of the Light Elements


Since the 1970s it has been believed that the light elements Li, Be, and B are made by the spallation of cosmic rays (CRs; primarily energetic protons and alpha particles) on nuclei of C, N, and O in the interstellar medium. Abundances of the light elements have in fact been used to infer the existence of a large flux of low energy CRs which are kept from our direct detection by solar modulation but which should efficiently produce Li, Be, and B. Our data contradicts this.

The Hubble Space Telescope has been used to obtain spectra of the boron 2500 Å region in eight galactic halo stars ranging from [Fe/H] = -0.3 to -2.96. The sample includes the most metal-poor (and presumably oldest) star ever observed for boron. Spectrum synthesis using latest Kurucz model atmospheres has been used to determine B abundances for each star, and particular attention paid to the errors of each point, to permit judgement of the goodness-of-fit of models of galactic chemical evolution.

None of the standard models of galactic chemical evolution fit the data; their predicted increase of light elements with time is too rapid. A straight line of slope 0.98 gives an excellent fit to all available data. There is little indication of a change in slope between halo and disk metallicities, and the B/Be ratio is typically 10. These data strongly suggest that the production of light elements is by CR spallation, but in a “primary” process, not a “secondary” one in the interstellar medium. We favor a model of light element production originally suggested by Duncan, Lambert, and Lemke (1992) and developed by Ramaty et al. (1996), which reverses the previously-accepted one. In the new model spallation occurs when high energy CN,O nuclei hit protons and He nuclei. This occurs in the vicinity of massive supernovae in star-forming regions, where the flux of energetic O, and to a lesser extent C, and N nuclei feed this process and where the nuclei can be accelerated to the required energies. The new model may also explain the long-standing problem that the 11B/10B ratio observed in CRs was not that predicted by the models of the 1970s.

We agree with Casse et al. (1995) that gamma-ray emission recently detected by the CGRO Satellite as coming from the Orion Nebula star-forming region and identified with excited states of O and C may be direct evidence of this process in action.

On the Origin of the High Lithium Abundance in the Halo Star BD+23 3912

C.P. Deilanyis (Yale Univ.), J.R. King (Univ. of Texas), A.M. Boesgaard (Univ. of Hawaii)

The Li abundance of the halo star BD+23 3912 ([Fe/H] = -1.5) lies a factor of 2–3 above the Spite plateau. This remarkable difference could reflect either less-than-average stellar Li depletion from a higher primordial Li abundance (as predicted by the Yale rotational stellar evolution models), which may have interesting implications for Big Bang nucleosynthesis, or the extraordinary action of Galactic Li production mechanisms (or both). We use our high resolution, high S/N Keck HIRES spectrum of BD+23 3912 to determine the s-process element abundances and #Li/He ratio in this star. These values serve as signatures for two possible Li production scenarios: the “Be transport mechanism in AGB stars, and cosmic ray interactions with the ISM. The remarkable abundances of Y, Zr, Ba, Nd, and Sm that we derive argue against a significant contribution to this star’s excess Li from AGB production mechanisms carrying an s-process signature. Our conservative upper limit of #Li/He=0.15 (compared to 0.25–0.50 expected from cosmic ray production) argues against cosmic ray + ISM interactions as the source for the excess Li, unless Li depletion from an even higher abundance has occurred with preferential #Li depletion. Highly speculative RGB production scenarios also seem unlikely given the normal Na and Al abundances we find and the normal C and O abundances determined by others. While the high Li abundance in BD+23 3912 is consistent with that expected from Yale rotational models having a lower-than-average initial angular momentum, future observations of s-process elements (particularly 12C) produced in supernovae should provide additional constraints on any enrichment scenarios seeking to explain the large Li abundance of this interesting star.

Lithium in Young Solar-Type Stars in the Orion Nebula Region

L.M. Rebull and D.K. Duncan (U. Chicago)

Lithium abundances have been determined for 27 stars in the Orion Nebula region with V = 12–14, and (B–V) = 0.5–1.2. All of the stars are within 20 arc minutes of the Trapezium; they range from approximately 1.0 to 1.6M☉ and from 10⁶ to 10⁷ years old. Approximate chronological ordering of the stars is possible from their location in the HR diagram, but they show no obvious evolutionary sequence of lithium depletion. In particular, the trend seen in the Pleiades, that faster rotators tend to have more lithium, is not seen here. There is no obvious correlation in the Orion stars between Li and v sin i. On the average, the stars in the present sample with (B–V) = 0.8–1.4 have greater Li abundances than similar stars in the older Pleiades cluster. One can infer that the process which depletes Li in these late-type stars requires more time to act than the ages of this Orion sample.

The status ofParenago 1799 as an ultra-fast rotator (UFR) (Walker 1990) is confirmed; it is shown that the star is rotating near breakup velocity. However, there are fewer UFRs in the present sample that in the Pleiades sample of similar size. The two T Tauri stars in the binary system Parenago 1540 have similar lithium abundances, suggesting similar depletion histories, and consistent with the findings of Lee et al. (1994).

The apparent very high Li abundances of the stars Parenago 1643 and 1929 are shown to be an artifact of their apparent colors; when newly-determined spectral types are used as temperature indicators, more typical lithium abundances are found. Similarly, we have used spectral types from Duncan (1993) to refine the colors and thus improve our estimates of Li abundances for Pi477 and Pi518.

The 6Li Abundances of α Cen A and B and the Sun

J.R. King (U. Texas), C.P. Delilanyis (Yale U.), A.M. Boesgaard (U. Hawaii)

We present high resolution high S/N spectra, obtained at the CTIO 4-m, of the Be II 3131 Å region in the metal-rich solar analog α Cen A and its companion α Cen B. Be abundances are derived relative to the Sun in a consistent fashion via spectrum synthesis. For α Cen A, we find [Be/H] = +0.20±0.15 where the error reflects random uncertainties at the 1σ confidence level; systematic errors of ~0.1 dex are also possible. Analysis of α Cen B is more uncertain since inadequacies in the linelist, which was calibrated with Solar data, may manifest themselves in cool metal-rich dwarfs. Our analysis suggests [Be/H] = +0.05. We also consider numerous uncertainties in the Solar photospheric and meteoritic Be abundances and conclude that it is likely the former value is depleted relative to the latter by 0.1–0.5 dex. Even a slight real depletion in solar photospheric Be coupled with the observed Li depletion of only ~2 dex would favor a slow (possibly rotationally-induced) mixing mechanism in addition to standard model burning at the base of the convection zone. If the difference in the Be abundances of α Cen A and B is real, it too would strongly suggest the action of additional mixing mechanisms. The light element abundances of the Sun and α Cen A (and other Solar analogs) are not grossly dissimilar. Thus, the idea that standard models and the current solar photospheric Li and Be abundances are discrepant because the Sun is a lone “oddball” is doubtful. We consider the issue of the unidentified blending feature(s) in the 3131.065 Å Be II region: a single significant blending feature could possibly fit the solar spectrum if it lies near 3131.02.