The Light Element Abundances

A LIGHT REVIEW OF THE RECENT ESO/EIPC WORKSHOP

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The ESO/EIPC Workshop on *The Light Element Abundances* was held during the week of May 23 at the Elba International Physics Centre on the Island of Elba. The 78 participants, only a small number of whom even noticed their email exile, represented the major fraction of the active researchers in this field.

The main focus of the workshop, the abundances of the elements with $Z \leq 5$, encompasses a very broad range of topics in astronomical research. These stretch from the synthesis of elements in the early Universe through stellar and galactic evolution to the Intergalactic Medium. The interplay between the theorists and observers in these seemingly diverse topics generated interesting and at times lively exchanges, just as a workshop should.

New observational opportunities with the Keck Telescope, with the refurbished HST, and with observational procedures that push old telescopes to new limits provided the most exciting new results.

The recently reported Keck observations of an absorption feature in the spectrum of Q0014+813 (Songaila et al., 1994, Carswell et al., 1994) which has been interpreted as a strong deuterium feature was touched on by many speakers. Curiously the standard Big Bang Nucleosynthesis (BBN) can accommodate almost a factor of 10 more D than is seen in the local ISM. However, theories of galactic evolution and the ^{3}He abundance cannot easily be made to agree with such a high value for D. Several participants suggested (or hoped) the "deuterium feature" in Q0014+813 would prove to be due to a weak hydrogen cloud.

Keck observation of Be in several low metallicity stars (Boesgaard) may be showing a plateau in the Be abundance which would present difficulties for theory if true. However, more observations are needed.

HST provided two of the most beautiful new pieces of data. Linsky presented spectra of D lines in the local ISM of unprecedented quality. His results confirm and strengthen the previous values for the abundance of D in the ISM. Jakobsen presented a truly convincing spectrum of a He II absorption feature at rest wavelength of 304 Å. This feature was seen in the spectrum of a high redshift quasar where the original He II line was redshifted to the region accessible to HST. Essentially no radiation at all was seen shortward of 304 Å suggesting that the Universe is opaque at these wavelengths. This is the first time the presumed diffuse intergalactic medium has been detected.

The ^{7}Li/^{6}Li isotope ratio determination is being measured in stars and in the ISM using improved data and methodology. Nissen reviewed the observational situation in old stars and showed convincing evidence that his techniques can determine this important isotope ratio. Lemoine showed new observations of exceptional quality to determine this ratio in the ISM toward Zeta Oph. The ^{7}Li/^{6}Li ratio in the ISM is close to solar or slightly below.

The new and old of BBN was reviewed by Audouze and elaborated on by Hoyle and Steigman. Hoyle in particular produced a characteristically bold alternative to the BBN by proposing that the light elements form in unusually hot and dense fireballs which are the end products of decay of Planck particles at 10^{-43} sec. This theory apparently can produce similar abundances for the light elements as does the BBN theory. In spite of this and over the silent protests of Burbidge, who had left early, Schramm proclaimed in his summary that the Big Bang is still healthy and basically the only game in town.

Theoretical models for galactic evolution of the light elements were the focus of many authors. Whether the observed total of D+^{3}He was consistent with the BBN picture and galactic evolution theory occupied the discussions by Steigman, Tosi, and Galli; new observations by Rood and his colleagues of galactic ^{3}He did not show a pattern consistent with an overall chemical enrichment scenario, and only added to the perceived problems if the deuterium mentioned above is taken seriously. Clearly, a further advance in understanding of this area requires less data. Reeves discussed the relations between the boron isotopic ratio and galactic cosmic rays, while Matteucci and Kunth each presented models of galactic evolution involving various stellar processes and mixing. The motto for this part of the meeting was "Those who cannot destroy an element are destined to produce it" – and so they did, in a dense and tangled thicket of parameters, although the final fits were always termed "predictions" by their perpetrators. Beckman, however, distinguished himself by bravely presenting a new and quite plausible model in which low energy cosmic ray $\alpha+\alpha$ reactions combined with an adequate chemical evolution model intriguingly reproduced the dependence of Li on Fe in the galactic disk, as well as fairly representing aspects of Be and the Li and B isotopic ratios. He was also able to explain the observed delay in the onset of Li production compared with that of Fe.

Lithiums's study has far to go, and so, appropriately, almost all of Thursday, and more, was devoted to this particular element. Faulkner presented a self-consistent, and purely classical, parameter free explanation of the Hyades G- and K-dwarf (Li, T_{eff}) relation that appears to resolve this 30-year-old problem. Deliyannis not only discussed Be- (in addition to Li-) depletion in stars, but was a persistent proponent of the view that Li depletion was dominated by age and rotational spin-down considerations. Pallavicini produced evidence from tidally locked binaries tending to support the idea that in them, at least, rotationally-induced mixing played a part in the Li depletion. However, when he remarked that the picture was greatly confused in Pop I field stars, perhaps by the influence of other parameters, Deliyannis rose smoothly to interject (and to hoist himself upon) one of the best petards of the meeting: "You need to know the *complete* rotational and mass-loss history of a star before you can predict its surface lithium content." How such post-pre-science was to be achieved remained unclear. His rotational enthusiasm remained undampened even when Soderblom revealed that new Keck HIRES observations of Li in low-mass Pleiades stars ($T_{eff} \sim 4200 \pm 300$ K) suggested that the previously seen correlation between excess Li and excess rotation is weak or absent – or, indeed on the face of the evidence presented, inverted!

Nevertheless, the Light Element Abundances is hardly a topic to be taken lightly and the proceedings should prove to be a tome of some intellectual weight.

References

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Songaila, A., Cowie, L.L., Hogan, C.J., and Rugers, M., *Nature*, **368**, 599 (1994).