The light elements Li, Be and B (LiBeB) play a unique role in astrophysics. The Li abundance of old halo stars is a key diagnostic of Big Bang nucleosynthesis (BBN), along with \(^4\)He and \(^2\)H. The essentially constant Li abundance \((\text{Li/H} \approx 2 \times 10^{-10}, \text{Spite plateau})\) as a function of metallicity \([\text{Fe/H}]\) for low metallicity stars \((\text{[Fe/H]} < -1)\) is believed to be the primordial abundance resulting from BBN. \([\text{Fe/H}] \equiv \log(\text{Fe/H}) - \log(\text{Fe/H})_{\odot}\), where \(\text{Fe/H}\) is the Fe abundance by number relative to H and \((\text{Fe/H})_{\odot}\) is the solar system value.

The rare and fragile LiBeB nuclei are not generated in the normal course of stellar nucleosynthesis and are, in fact, destroyed in stellar interiors, a characteristic that is reflected in their very low abundances. Cosmic-ray interactions contribute to their production, but only \(^6\)Li, \(^9\)Be and \(^{10}\)B are entirely cosmic-ray produced. Neutrino induced spallation, \(^{12}\)C(\(\nu, \nu'\)p)\(^{11}\)B appears to play an important role in the origin of B by producing the excess \(^{11}\)B needed to account for the B isotopic ratio in meteorites which exceeds the predictions of all viable cosmic-ray scenarios. While reactions on metals (primarily C and O) contribute to all of the LiBeB nuclei, reactions of fast \(\alpha\) particles on ambient He produce

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both $^7$Li and $^6$Li, and are the dominant source of the latter. Nucleosynthesis in a variety of other Galactic objects, including Type II supernovae, novae and giant stars produce the bulk of the $^7$Li at epochs when [Fe/H] exceeds about -1.

Traditionally, the cosmic-ray role in LiBeB evolution was investigated by assuming that at all epochs of Galactic evolution cosmic rays with energy spectra similar to those observed in the current epoch are accelerated out of the average interstellar medium and interact in the interstellar medium (ISM), mostly with C, N and O. This GCR paradigm, however, appears to be in conflict with recent measurements of Be and B abundances in low metallicity halo stars, achieved with the 10 meter KECK telescope and the Hubble Space telescope. The GCR paradigm predicts a quadratic correlation of Be and B vs. Fe, as opposed to the data which show a quasi linear correlation. As a consequence, the paradigm has been modified (Cassé et al. 1995, Nature, 373, 318; Ramaty et al. 1996, ApJ, 456, 525) by augmenting the cosmic rays accelerated out of the average ISM with a metal enriched component confined predominantly to low energies ($\sim 100$ MeV/nucleon) and thought to be accelerated out of the winds of Wolf-Rayet stars and the ejecta of supernovae. More recently, it was suggested (Lingenfelter et al. 1998, ApJ, 500, L153; Higdon et al. 1998, ApJ, 509, L33) that the cosmic rays themselves are accelerated mostly out of supernova ejecta rather than the average ISM, implying that the source material of the cosmic rays would be metal enriched at all epochs of Galactic evolution. Both of these models now converge towards acceleration by shocks in superbubbles, but they differ in the employed particle energy spectra, a distinction that could be tested by nuclear gamma-ray line observations. However, the effect is only marginally detectable by present generation gamma-ray telescopes.

Light element research thus impacts several important astrophysical problems, specifically BBN, the origin of cosmic rays, Galactic chemical evolution, and gamma-ray
astronomy. These were then the topics of the Conference and they will be covered in detail in the upcoming Proceedings. Here we summarize some of the highlights.

Critical considerations of the flatness of the Spite plateau were presented by Paolo Molaro. These are essential for establishing the primordial Li abundance. An important issue in this context is the amount of Li destruction (if any) in the observed stars. Marc Pinsonneault and Sylvie Vauclair addressed this problem. Another venue for establishing the primordial nature of Li in connection with binaries was discussed by Francois Spite. The relationship of the light element data to BBN was reviewed by Keith Olive.

The $^6$Li observations in low metallicity stars were reviewed by Lewis Hobbs. There are now good indications that $^6$Li is present in such stars, with an abundance of a few percent relative to $^7$Li and a factor of several tens relative to Be. The abundance ratio relative to Be, compared with the expected ratio from the various cosmic-ray scenarios, implies that $^6$Li could not have been severely depleted in the stars where it is detected. Consequently, since $^6$Li is more fragile than $^7$Li, the $^7$Li depletion should also be small. The abundance ratio relative to $^7$Li shows that cosmic-ray interactions could not have made a significant contribution to the Li/H of the Spite plateau. All of these reinforce the finding that the plateau value indeed represents the correct primordial abundance. $^6$Li so far has been detected in only two stars. As its production history could be quite different from that of Be (being very efficiently produced in interactions involving only He, unlike Be which requires the spallation of metals), future observations over a broad range of metallicities could lead to interesting surprises.

The very important new data on O abundances in low metallicity stars were presented by Ramon Garcia Lopez (see Israeli et al. 1998, ApJ, 507, 805). Contrary to previous data, the new observations, if confirmed, show that O/Fe is a monotonically increasing function of decreasing metallicity, reaching values that exceed the solar ratio by a factor of
Some of this increase is due to the absence of Type Ia supernovae in the early Galaxy. The additional increase is not well understood, it could be due to low Fe yields relative to O in the first generation of core collapse supernovae, or possibly due to mixing effects since, as pointed out by Audouze and Silk (1995, ApJ, 451, L49) the ISM of the early Galaxy, being metal enriched by only a small number of core collapse supernovae, could be quite inhomogeneous. In any case, the enhanced early Galactic O abundance makes cosmic-ray acceleration out of the average ISM more efficient. This effect, coupled with the possible lower Fe yield per supernova, allowed Brian Fields and Keith Olive to show that cosmic-ray acceleration out of the average ISM, hitherto believed untenable, could be viable. Their model also implies a decrease of $^6$Li/Be as a function of increasing metallicity, a result which appears to be consistent with the fact that the early Galactic ratio mentioned above probably exceeds the meteoritic ratio at solar metallicity.

A critical discussion of the NLTE effects, which are essential for the abundance determinations, particularly that of B, was given by Dan Kiselman. Douglas Duncan reviewed the B observations and Dieter Hartmann discussed the neutrino induced processes in core collapse supernovae, that in particular lead to the production of $^{11}$B. As already mentioned, this process provides a plausible explanation for the excess $^{11}$B measured in meteorites. Stellar evolution, another very important ingredient necessary for understanding the implications of the light element data, was discussed by Marc Pinsonneault. The status of Galactic nuclear gamma-ray line observations, showing that the previously reported observations of Orion are no longer valid, was reviewed by Hans Bloemen. In the absence of nuclear gamma-ray data, the detection of broad soft X-ray lines (particularly the lines of O just below 1 keV) resulting from electron capture and excitation on fast ($\sim$1MeV/nucleon) ions, could provide independent information on the existence of low energy cosmic rays. This topic was discussed by Vincent Tatischeff. The capabilities of the gamma-ray imaging
and spectroscopic mission INTEGRAL, to be launched soon, were discussed by Volker Schönfelder and Bertrand Cordier.

Current epoch cosmic-ray observations of the electron capture radioisotope $^{59}$Ni and its decay product $^{59}$Co, with an instrument on the currently active ACE mission, were presented by Robert Binns. $^{59}$Ni decays by electron capture with a half life of $7.6 \times 10^4$ years. However the decay is suppressed if the acceleration time scale is shorter than the lifetime because the atom is stripped as it is accelerated (Cassé and Soutoul 1975, ApJ, 200, L75). The fact that much more $^{59}$Co than $^{59}$Ni is observed, suggests a delay ($\sim 10^5$ years) between nucleosynthesis and acceleration. This makes it unlikely that supernovae accelerate their own ejecta, but still allows cosmic-ray acceleration from metal enriched superbubbles, as in the Higdon et al. model mentioned above.

Several theoretical papers on cosmic-ray origin and acceleration mechanisms were presented. Jean-Paul Meyer and Donald Ellison reviewed their previously published model (Meyer et al. 1997, ApJ, 487, 182; Ellison et al. 1997, ApJ, 487, 197) in which the current epoch cosmic rays originate from an average ISM of solar composition and interstellar dust plays an important role in determining the abundances. They also discussed the shortcomings of the recently proposed model (Lingenfelter et al., 1998, ApJ, 500, L153) in which each supernova accelerates its own freshly produced refractory metals. Maurice Shapiro reviewed his previously proposed model based on the preacceleration of the cosmic rays by coronal mass ejection driven shocks on low mass, cool stars. Acceleration in superbubbles was discussed by Andrei Bykov and Etienne Parizot, who emphasized that the conditions in the superbubbles that would to lead to cosmic rays with hard energy spectra at low energies up to a cutoff at an energy which is still nonrelativistic. These are the low energy cosmic rays which have been postulated to produce the bulk of the Be at low metallicities (see Vangioni-Flam et al. 1996, A&A, 468, 199). On the other hand, as
pointed out in the publication of Higdon et al., since these giant superbubbles are thought
to fill up a large fraction of the ISM, they are the most likely site for the acceleration of the
cosmic rays, which of course show no cutoff up to very high ultrarelativistic energies. Thus,
it is still not clear whether the postulated Galaxy wide low energy cosmic-ray component
exists, a question that should be resolved by future gamma-ray line observations.

In summary, LiBeB research indeed spans a broad range of interesting problems that
will be covered in the planned Proceedings.