Second, the fact that the λ Boo stars have near normal $v \sin i$'s, whereas the Ap stars rotate slowly (they have $v \sin i \sim 40$ km/sec) implies that if these stars are part of an evolutionary sequence then it must run in the direction

$$\text{Normal A star} \rightarrow \lambda \text{ Boo star} \rightarrow \text{Ap star},$$

and that angular momentum is lost at some stage, perhaps in the red-giant phase.

All the known λ Boo stars, with the exception of ADS 3910B, are brighter than about $m_v = 5.0$. Thus many more such stars should be easily discoverable among the A stars fainter than $m_v = 5.0$. The writer is at present searching for additional λ Boo stars brighter than $m_v = 5.5$ by looking for stars in Eggen's (1963) list that have discrepancies between the color and the spectral type, characteristic of λ Boo and 29 Cygni. This kind of search should be pursued, for it may lead to the discovery of λ Boo stars that have sharper lines and that are easier to analyze spectroscopically than those found so far.

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THE LITHIUM ISOTOPE RATIO IN TWO HYADES F STARS

The ratio of Li^6 to total lithium has been reported to range from zero to one-third in a number of stars in the general vicinity of the Sun (Herbig 1964; Wallerstein 1965). In this note we report on the lithium isotope ratio in two stars in the Hyades, a cluster that is particularly interesting because it consists of a group of stars of presumably common origin. In addition, the age and chemical composition of the Hyades are fairly well established, and the ratio of Li/Ca in twenty-three Hyades stars has been determined (Wallerstein, Herbig, and Conti 1965). Furthermore, the proximity of the Hyades allows observations of main-sequence stars with a considerable range in color, thus permitting us to investigate the possible effect of the deepening of the outer convection zone with advancing spectral type.

Four spectrograms at 8 Å/mm were secured for each of the two stars with the 40-inch camera of the 120-inch coudé spectrograph. Most of the lines previously used by Wallerstein (1965) plus four additional lines were employed to obtain the stellar radial velocity from each plate. The plates were measured on an automatic measuring engine that displays the line profile on an oscilloscope screen (Tomkins and Fred 1951). The data reduction was similar to that described by Wallerstein (1965); a spectrogram of α Lib B served as a standard. This plate, which had been measured three times visually, was measured on the automatic measuring engine and yielded a wavelength of the lithium line of λ 6707.823 Å, while the visual measures yielded λ 6707.819 Å. The agreement seems satisfactory.

The wavelengths of the lithium line on each plate are listed in Table 1. For each star we have also listed the color and logarithmic ratio of Li/Ca as compared to the Sun. In addition we list the value of $Li^6/(Li^6 + Li^7) = (\langle \lambda'_{Li} \rangle - 6707.811)/0.158$, where $\langle \lambda'_{Li} \rangle$ is the mean wavelength for each star. The values of λ'_{Li} determined from the individual plates were weighted inversely by their probable errors to form $\langle \lambda'_{Li} \rangle$. There is no evidence for appreciable amounts of Li^6 in either of the two Hyades stars.

The uncertainty in the mean wavelength for 45 Tauri is difficult to estimate because the individual plates exhibit agreement that is much better than can be expected from the probable error in the radial velocity of each plate. The quoted probable error is *not*

TABLE 1

DETERMINATION OF THE RATIO $Li^6/(Li^6 + Li^7)$

Star	$B-V$	[Li/Ca]	λ'_{Li}(6707+)	p e (Å)	$\langle \lambda'_{Li} \rangle$	p e (Å)	$Li^6/(Li^6+Li^7)$
45 Tau .	0 36	2 0	0 811	0 053	6707 817	0 018	+0 04±0 11
			816	037			
			822	030			
			814	035			
HD 27808	0 52	1 5	816	032	6707 815	0 017	+0 03±0 11
			815	035			
			844	037			
			0 791	0 031			

computed from the residuals of the individual wavelengths but is taken to be $1/n^{1/2}$ the mean of the individual probable errors (inversely weighted as were the wavelengths). In the case of HD 27808, however, the scatter of the four measurements is consistent with the probable error in an individual measurement.

Observations of only two stars are not sufficient to rule out the possibility that there are wide fluctuations within the Hyades. But regrettably there are no other sharp-lined stars in the Hyades brighter than seventh magnitude or bluer than $B - V = 0.52$ with the exception of HD 27561 and the metallic-line stars, none of which shows a lithium line. Thus we will provisionally accept as a fact that there is no Li^6 in the Hyades stars with colors between $B - V = 0.36$ and 0.52.

Recent calculations (Bodenheimer 1965) have shown that it is possible to explain the general decrease in the total lithium content of the Hyades main-sequence stars near $B - V = 0.70$ in terms of convective depletion during the pre-main-sequence contraction. The calculations, which started in the fully convective contraction phase, were carried over to the main sequence and continued until lithium depletion in the stellar envelope became negligible. We will now examine the same calculations to see what they predict for Li^6 and Li^7 separately. In Figure 1 we plot both the observed and calculated ratios of $Li^6/(Li^6 + Li^7)$ versus $B - V$ on the main sequence, where the calculations were terminated. The upper curve in the figure corresponds to an initial pre-main-sequence abundance ratio $Li^6/(Li^6 + Li^7)$ (by weight) of 0.35. This value is based upon the highest observed ratios in normal stars and also upon the experimental spallation production ratio reported by Bernas, Epherre, Gradsztajn, Klapisch, and Yiou (1965). The lower curve corresponds to an initial ratio of 0.08, the observed terrestrial and meteoritic value.

We note that the theory and observations are not in complete agreement. The theoretical curves predict substantial depletion of Li^6 at $B - V = 0.52$ where no Li^6 is observed. Slight changes in the theoretical parameters, such as the inclusion of line opacities, changes due to uncertainties in reaction rates, or adjustment of the mixing length, could shift the curves far enough to the left so as to predict essentially complete depletion at this color. However, the calculations do not predict depletion of Li^6 at $B - V = 0.36$, even taking into account uncertainty in the theory. The observed ratio of $Li^6/(Li^6 + Li^7)$ differs from the predicted value, assuming 35 per cent initial Li^6, by $2\frac{1}{2}$ probable errors, which is a decisive amount. We could arbitrarily adjust such theoretical parameters as

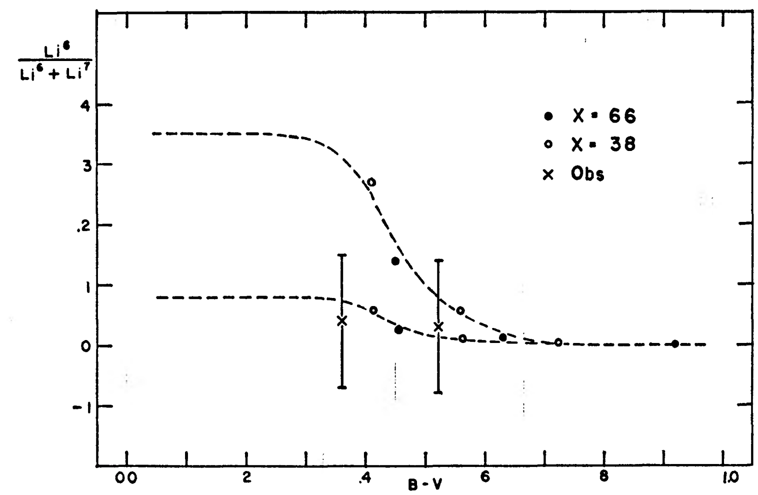

FIG. 1.—The ratio $Li^6/(Li^6 + Li^7)$ for theoretical contracting models which have reached the main sequence, plotted as a function of $B - V$ on the main sequence. The two observed points are indicated by crosses. Open circles indicate models with hydrogen concentration $X = 0.38$, which gives an approximate fit to Eggen's mass-luminosity relation for the Hyades. Filled circles correspond to the solar value $X = 0.66$. The upper dashed curve is based on an initial ratio of 0.35, while the lower curve is based on an initial ratio of 0.08.

the mixing length in order to force the convection to be deep enough in pre-main-sequence evolution to result in depletion of Li^6 in a star that arrives on the main sequence at $B - V = 0.36$. However, if this were done, the calculations would indicate destruction of Li^7 in stars with $B - V = 0.55$ on the main sequence, contrary to observations. No adjustment of the usual parameters appreciably changes the interval in $B - V$ between the color at which 50 per cent of the Li^6 is depleted and the color at which 50 per cent of the Li^7 is depleted, approximately 0.18 mag. in $B - V$. However, the interval of stars in the Hyades with Li^7 but no visible Li^6 extends from $B - V = 0.36$ to at least $B - V = 0.66$: at $B - V = 0.66$ on the Hyades main sequence the observations of Wallerstein *et al.* (1965) indicate that Li has been substantially depleted; therefore we infer that Li^6 is not present at that color since it is depleted by (p, α) reactions more readily than is Li^7. The effect of initial composition in the model sequences has been tested; both Eggen's (1963) mass-luminosity relation and the solar-mass–luminosity relation and their corresponding ratios of hydrogen to helium yield nearly the same depletion of Li^6 and Li^7 for stars arriving on the main sequence at the same luminosity.

We suggest two possible explanations that provide consistency of the observations with the calculations. The first explanation involves relaxing our provisional assumption