We are aware that the Wilson-Devinney model cannot well describe a symbiotic binary since it supposes the stars to have a well-defined surface. Thus, it cannot handle the gaseous nebula. However, if the light of the system is dominated by the cool secondary (which can be treated as a normal star), a reasonable agreement between the calculated and the observed light curve may be found with parameters for the dominating star which are not altogether wrong. We therefore restrict our calculations to the *b* and *y* band data. It is then in fact possible to obtain a satisfactory fit. The calculated *y* light curve is shown in Figure 1 superposed upon the observed data points. The suspicion that the Wilson-Devinney model cannot be applied to data in spectral bands where the secondary does not dominate was confirmed by test calculations for the *u* and *v* bands. Here, a satisfactory fit proved not to be possible.

When performing a light curve fit it is advisable to fix as many free parameters as possible to values determined otherwise or to plausible ones, in order to relieve problems arising from correlations between them and to increase the reliability of the remaining parameters. In the present case we fixed the period to 283 days and the primary star temperature to 5000 K, appropriate for a late G-type star. Furthermore, we assumed the orbital eccentricity to be 0, the albedos of both components to be 1 and the gravity darkening parameter of the primary to be 0.32.

The results of a simultaneous fit to the *b* and *y* light curves are given in Table 2. Here, i is the orbital inclination, T_1 the temperature of the primary, q the mass ratio defined as mass of secondary to primary, L the monochromatic luminosity, and Ω the dimensionless surface potentials. Ω_c is the potential of the Roche limit. σ is the standard deviation of the observed data points from the fitted ones.

It turns out that the light curve calculated with these parameters reproduces the observed one well. The G star is close to filling its Roche lobe as indicated by a comparison between its surface potential and the potential of the Roche limit. The system is seen under an angle where grazing eclipses of the primary are to be expected. For reasons outlined above, the parameters of the latter are, of course, unreliable.

It must be emphasized that these results are only preliminary. However, they confirm that the simple heuristic model outlined above is not altogether wrong and may serve as a starting point for more detailed investigations.

The long-term observations of BD −21°3873, although they could yield only few data so far, have thus already provided some interesting results. A further analysis of the available data and a more complete coverage of the light curve will certainly lead to a better understanding of the system. We therefore changed the priority of BD −21°3873 within the LTPV programme and gave it the highest weight within group 3. We hope that it will also be possible to obtain spectroscopic observations of the star around the orbit, although at a period of 283 days this will not be easy for someone who can only observe as a Visiting Astronomer and has no constant access to suitable observing facilities.

Table 2: *Best fit model parameters for BD −21°3873*

	b	*y*
i	68°	
T_1(K)	20100	
q	1.8	
Ω_1	10.7	
Ω_2	5.2	
Ω_c	5.0	
$L_2/(L_1 + L_2)$	0.835	0.968
σ (mag)	0.026	0.024

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The Importance of Lithium

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Recent developments increasingly emphasize the importance of lithium. Its primordial abundance is well known to severely constrain the nucleon density in the Universe (Kawano, 1988); it is now thought to be the first observational test to try to discriminate between non-standard cosmological models, such as the inhomogeneous ones inspired from the quark-hadron transition (Reeves, 1988).

Actually, the use of lithium as a cosmological barometer encounters a major obstacle: the uncertainty in the determination of its primordial abundance. Spite and Spite (1982) suggest that the constancy in the observed values of the ^{7}Li abundance toward very metal-deficient stars (Pop II) represents its primordial abundance, Log(Li/H) = −9.5 ± 0.2. In the interstellar medium and towards Pop I stars, the derived value is Log(Li/H) = −8.9 ± 0.2. If the Pop II value is typical of the primordial one (which seems to be the case, see Vangioni-Flam et al., 1989), then the explanation for a higher Pop I value becomes a crucial astrophysical issue. Furthermore, it appears that this value is slightly lower than the one measured in the solar system, derived from meteoritic measurements.

Lastly, the ^{7}Li abundance seems to be still increasing, for in the very young stars of the T Taurus molecular cloud, the abundance observed is on the average twice the Pop I value. The lithium evolution models have then to account for this galactic enrichment in ^{7}Li. Amongst them, it was suggested that ^{7}Li was produced by a slow mass-loss process in certain red giant stars (Scalo, 1976), in nova bursts under certain chemical conditions (Starrfield et al., 1978), and recently in supernova shocks (Dearborn et al., 1989).

While the red giant and nova models lead to an overproduction of ^{7}Li, the supernova process would account for the galactic enrichment in ^{7}Li and ^{11}B, two unresolved problems within the spallation scenario. Furthermore, it could explain the large difference between the meteoritic isotopic ratio ^{7}Li/^{6}Li = 12.5 and the only published value of the interstellar isotopic ratio : 38 ($\geq$ 25) towards ς Ophiuchi (Ferlet and Dennefeld, 1984) by enrichment from a recent supernova within the Sco-Cen OB association. If confirmed, this model might reject some models of primordial nucleosynthesis, especially those trying to accommodate a high value (=1) of the baryonic density and inspired from the quark-hadron transition for the prediction of primordial ^{7}Li abundances up to Log(Li/H)= −0.7.

This clearly shows the importance of deriving a precise value for the interstellar lithium isotopic ratio along several lines of sight. It would permit to test the different models of galactic production and depletion of lithium, improve the knowledge of the chemical evolution of the Galaxy, and as well help to determine the ^{7}Li primordial abundance. However, as lithium is not very abundant in the interstellar clouds, the observed lines are extremely weak. The equivalent width is about 0.7 mÅ towards ς Oph, which is located behind a large diffuse cloud. Moreover, the stronger ^{6}Li line is blended with the weaker ^{7}Li line: the ^{7}Li line structure is a doublet at 6707.761-6707.912 Å, while ^{6}Li has the same structure red-shifted by 0.160 Å. Then, to measure the isotopic ratio, we have to derive the ^{6}Li abundance from its weaker line. According to the meteoritic ratio and the oscillator strengths, it is at least 25 times weaker than the stronger ^{7}Li line, i.e. an equivalent width of about 0.028 mÅ towards ς Oph!

Observations at the 3.6-m + Fibre Link to CES

The purpose of our investigation of interstellar lithium is to determine precisely the abundance of lithium along different lines of sight, here ϱ Oph, using the ESO 3.6-m Telescope linked to CES via fibre optics. This complex instrumentation is necessary to obtain a very high resolution ($\lambda/\Delta\lambda$ = 10^5), together with a signal-to-noise ratio as high as possible, in a still reasonable integration time. We determined a faint limit V~4 with the CAT+CES at this resolution for the S/N needed, showing that the 3.6-m is mandatory for such observations. We report here on five nights in June 1990 and July 1991.

We used the ESO General Fiber Optics (GFO) optic fibre connected at the Cassegrain focus of the 3.6-m telescope with an entrance slit width of 3.″4 on the sky. At the output end the image is projected on an image slicer, which produces 11 slices and aligns them on the entrance slit of the CES predisperser; this allows a better signal-to noise ratio without saturating the CCD. The CES is operated in the Long Camera mode at a resolving power of 100,000 at 6708 Å, giving a reciprocal dispersion of 1.88 mm Å or 0.028 Å per pixel, i.e. a resolution element of 67 mÅ or 2.2 pixels. We used the ESO CCD detector #9 of 1024×640 pixels with a responsive quantum efficiency of 75% at 6708 Å and a gain of 7.4 e^-/pix. The internal transmission of the optic fibre has a maximum at 8000 Å, being 95% at 6708 Å. The overall efficiency of the 3.6-m + fibre link + CES instrumentation allows a gain of 1.65 magnitudes at this wavelength, as compared to the CAT + CES (Avila and D'Odorico, 1988). In practice, at 6708 Å and under normal seeing conditions, about 30 min are required to obtain a signal-to-noise ratio of 700 for a star of magnitude 5.0.

The observed star, ϱ Oph, was chosen to be observed in June 1990 because it is reasonably bright (V = 5.0), its spectrum is featureless in the Li region (spectral type B2IV), it has a large reddening (E(B-V)=0.47) and a total hydrogen column density along the line of sight N(H)=72.10^{20} cm^{-2}, which proves the presence of very dense, diffuse interstellar clouds.

The observations revealed a very strong lithium absorption line, about 3 times stronger than towards ς Oph, making ϱ Oph the best candidate up to now for evaluating the interstellar lithium isotopic ratio. In July 1991, we made exposures of 1 hour each, because of the magnitude of ϱ Oph, and to avoid too many cosmic events. Indeed, the use of an image slicer broadens considerably the signal over the CCD perpendicularly to the dispersion, thus increasing the number of detected cosmic events. These events can however be easily removed before summing. The central wavelength was shifted slightly from one night to the other to identify possible systematic effects due for instance to bad pixels.

Each spectrum was reduced individually using the IHAP software at IAP in the following way:

– subtraction of the *bias*, i.e. the readout noise of the CCD, measured at different intervals to check possible variations; the dark current, or thermal leakage, very weak (2.5 e/h/pix), was taken into account;

– division by the response curve of the CCD to the spectra of a very bright star not showing any stellar or interstellar absorption in the wavelength range, here α Aql or β Cen. About 25 exposures per night of such flat-field exposures were done very close in time to the exposures of ϱ Oph. We experienced that this improves the signal to noise as the response curve to this flat-field star is much more similar to the observation itself than a flat-field lamp, especially with respect to the well-known problem of fringes; and

– we then averaged the signal over all of the CCD. Here the slices to be added were the central ones, where the signal between two consecutive slices is still important as compared to the noise level. The spectra were then combined taking into account all the revelant wawelength shifts as well as the heliocentric velocity correction for each exposure. The wavelength calibration is based on a thorium-argon lamp, observed several times throughout the night to check for possible variations. We found that the CES was stable within one pixel, i.e. 1.2 km/s; the internal accuracy is ~ 7 mÅ.

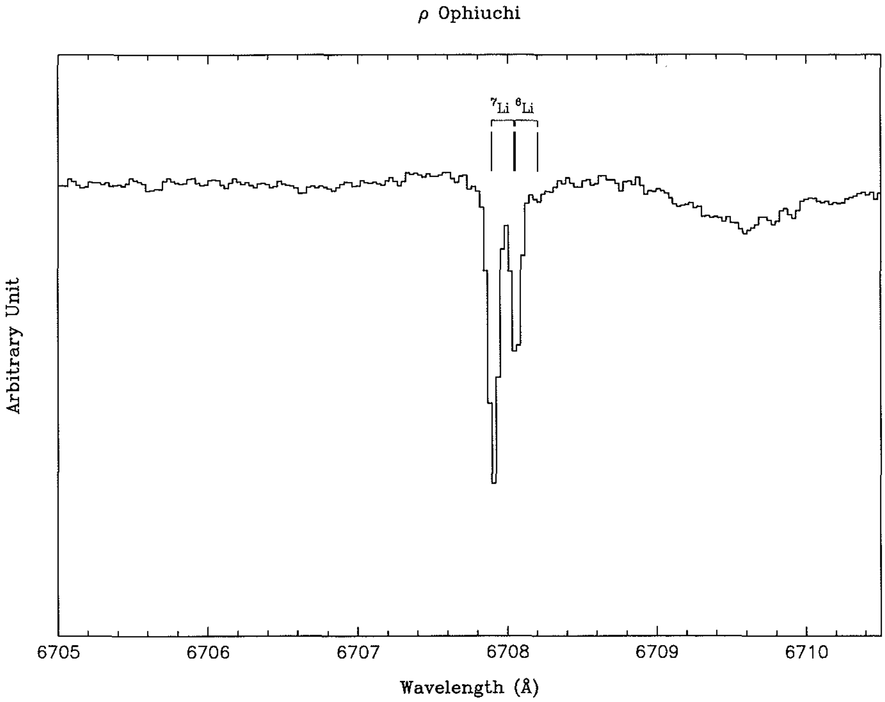
The spectrum shown in the figure on page 42 (enlarged in the Li region) represents a total integration time of 13 hours. The signal-to-noise ratio is about 2700 and the equivalent width for the total Li I lines is 2.1 mÅ. We measured this S/N on the blue side of the Li lines by dividing the mean signal by the root mean square noise (*rms*). There is a broad unidentified feature on the red side of the lines that possibly corresponds to the absorption by a diffuse interstellar band; this feature, near 6709.5 Å, is also seen towards all other stars observed in Li I.

The identification of the ^{7}Li lines is unquestionable; the interstellar heliocentric velocity is found to be −8.5 km/s, in very good agreement with the previous observations of ϱ Oph in Ca II-K and Na I-D lines (Hobbs, 1975: K-line at −7.3 km/s, D-line at −8.9 km/s). However, the detection of the weaker ^{6}Li line is questionable since the corresponding feature on the spectrum is only 1σ deep, and does not allow a precise measurement of its position. Still, we can estimate an upper limit for its equivalent width, hence a lower limit for the isotopic ratio. Indeed, at this wavelength, with the present resolution (R=100,000) and signal-to-noise ratio (S/N=2700), the limiting detectable equivalent width is 0.050 mÅ for a 2σ detection. Considering the total equivalent width for the Li I lines, this yields ^{7}Li/^{6}Li$\geq$13. This evaluation, although compatible with the solar system value, seems to favour a higher isotopic ratio, in possible confirmation of the only other measurement made towards ς Oph: ^{7}Li/^{6}Li=38 ($\geq$25). We estimate that a total integration time of 50 hours is needed with this instrumental configuration to confirm or not at 2σ this detection of the weaker ^{6}Li component.

Further speculations on this spectrum are still premature. Only a detailed analysis with the profile fitting method developed by Vidal-Madjar et al. (1977) and Ferlet et al. (1980 a, b) may help to evaluate with precision the interstellar lithium isotopic ratio. This method was already applied to the interstellar Li lines towards ς Oph by Ferlet and Dennefeld (1984), yielding the above-mentioned result. It offers the possibility of extracting all the information contained in the profile, particularly the velocity structure along the line of sight (previous articles indicate the presence of two components), and allows calculation of the blend between the isotopes lines. This will be the scope of a forthcoming paper on the present data.

While the study of the interstellar lithium isotopic ratio is of crucial importance for nucleosynthesis and chemical evolution, it is certainly not an easy task. The observation of extremely weak interstellar lithium lines towards relatively faint star requires a very efficient instrumentation. The 3.6-m + CES via fiber link fulfils this quite well, as can be judged by the quality of the present data, provided great care is taken during the observations and data reduction.

Moreover, observations in July 1991 with the CAT revealed new good candidates for the interstellar lithium ratio, especially ο Sco, and χ Oph, which were observed for the first time at this wavelength. Their total Li equivalent width have not been precisely estimated yet, but we hope to investigate these new lines of sight. We will also continue to accumulate photons from ϱ Oph to further improve the S/N in order to definitely detect the weakest ^{6}Li line. Still, the perspective of the VLT brings new hope for this difficult task; it should even allow measurements of the abundance of lithium in the Magellanic Clouds.



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On Flux Calibration of Spectra

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1. Introduction

In an *A&A* paper on spectroscopic reduction, two spectral correction functions for the spectral range 375 < λ[nm] < 900 were derived (Fluks and Thé, 1992). The first $\chi_e(\lambda)$, accounts for the depletion of stellar radiation in the Earth's atmosphere and the second, $\chi_s(\lambda)$, for the blocking of part of the radiation by the spectrograph slit. In the present paper we summarize the main results for those observers who are interested in our method but not in the mathematical part of the problem.

The atmospheric scattering and molecular absorption at ESO is given in Table 1, and using Table 3, one can correct for the blocking of part of the radiation by the spectrograph slit. We derived formulas for two slit positions: in the west-east direction in the horizontal plane and in the hour angle declination in the elevated plane. By applying our method, the spectral flux-calibration will be more accurate.

In the three (artificial) wavelength-calibrated spectra, shown in Figure 1, $f_1(\lambda)$ is the spectrum before entering the atmosphere (:= $F(\lambda)\chi_{resp}(\lambda)$, in which $F(\lambda)$ is the flux-calibrated spectrum and $\chi_{resp}(\lambda)$ is the instrumental response function), $f_2(\lambda)$ is the spectrum after its passage through the atmosphere and $f_3(\lambda)$ is the "observed" CCD spectrum.

$\chi_e(\lambda) = \chi_{sc}(\lambda)\chi_a(\lambda)$ is the spectral transparency function of the atmosphere in which $\chi_{sc}(\lambda)$ accounts for the scattering (Aerosol scattering and Rayleigh scat-