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AGB Stars Interferometric Signatures: Effects of possible Li-rich spots.

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Abstract. We propose to observe Asymptotic Giant Branch stars (AGB) with spectro-differential interferometric techniques in order to find new observational constraints to inner structure and evolutionary models of these stars. We examine the interferometric signatures created by possible heterogeneities on AGB stars surface due to local Li-enrichments or Li-rich spots and find that such heterogeneities, if they exist, could be detected with present or future interferometers.

In order to study interferometric signatures of an AGB star (i.e. visibilities and phases versus baseline), we first compute synthetic spectra of a typical carbon-rich star. For this purpose, we refer to Abia et al. (1999) where details of used model atmospheres, line lists and other input physics are given.

We consider a "normal" cool carbon star defined by $T_{eff} = 3200$ K, log g $= 0$, C/O $= 1.1$ and $^{12}C/^{13}C = 5$. The star spectrum is then computed by combining the spectral contributions of: (i) an uniform disk representing the AGB surface with $R_{AGB} = 20 \times 10^{-3}$arcsec (i.e. $R_{AGB} = 400 R_{\odot}$ at 100pc) and very low Li abundance ($A_{Li} = 0$) as observed for most AGBs, and (ii) a not centered Li-rich spot with arbitrarily $R_{spot} = 20\% R_{AGB}$ and a very large local Li enrichment ($A_{Li} = 4.5$). Such a Li abundance for the spot corresponds to those presently found in the more Li-rich AGB known to date. The resulting spectrum is the combination of the "normal" AGB and the Li-rich spot spectra, taking into account their proper emitting surface. We find that the total stellar spectrum of the hypothetic AGB with a Li-rich spot matches the spectrum of a classic Li-poor AGB star. A star would thus be classified as Li-poor if observed with classical spectrometric technics, although a Li-rich spot could be present on its surface. Interferometric observations have then to be undertaken to detect such possible surface heterogeneities.

We have then calculated visibilities and phases versus the baseline in different spectral channels around the Li6708 transition. The moderate spectral resolution considered ($R < 10\,000$) corresponds to that offered by current/future interferometers as the *Grand Interféromètre à deux Télescopes* (Observatoire de

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la Côte d'Azur). In the following spectral channels, the star appearance changes indeed drastically:

1. In the core of the Li absorption line (6708Å), where the Li-rich spot does almost not contribute to the stellar flux, the total spectrum corresponds to the one emitted by an uniform disk with a dark spot on it. The interferometric fringes phase varies strongly with the baseline in the line core.

2. In the wing of the Li line, the Li-rich spot slightly contributes to the stellar flux. The star appears as an uniform disk with a grey spot on it.

3. Outside the Li line, the Li-rich spot does not affect anymore the stellar spectrum. The star looks like a completely uniform disk since it is spherically symetric and no structures are present at its surface. The interferometric fringes phase is then always equal to zero.

Therefore, from the core of the Li line to outside this transition, the photocenter of the studied star is strongly displaced due to changes of the Li-rich spot spectral contributions. This leads to strong variations of the AGB interferometric signatures, specially for the phase. A Li-rich spot, if it exists, could thus be easily detected by interferometric observations with a relative precision of $\sim$1% for the visibility (such a precision measurement should be attained by the present/future interferometers). Furthermore, the variations of the interferometric fringes phase with respect to the baseline are much stronger (from $-\pi/2$ to $\pi/2$) and can therefore be measured much more easily. Phases differences or visibilities ratios between different spectral channels are indeed measured with the spectro-differential interferometric method. We can use this method here to get enough accurate relative measurements.

In summary, our simulations have shown that a very Li-rich spot on an AGB star with $R_{\text{spot}} \sim 10-30\% R_{\text{AGB}}$ or a larger spot ($R_{\text{spot}} \sim 50\% R_{\text{AGB}}$) with moderate Li-enrichment ($A_{Li} < 4$) does not strongly modify the stellar spectrum. Thus interferometric technics are requested to detect such configurations. We therefore propose that (i) AGB stars presently classified as Li-rich should have a large Li-enrichment over their whole surface, and (ii) AGB stars presently classified as Li-poor could have either no Li-enrichment at all **or** Li-rich spots could be present on their surface.

Other configurations and their interferometric signatures (several larger or smaller not centered Li-rich spots, line transitions of other elements interesting stellar evolution...) are under investigation (see also de Laverny & Lopez, 2000).

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References

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