Peculiar Versus Normal Phenomena in A-Type and Related Stars
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A SEARCH FOR λ BOOTIS STARS IN OB ASSOCIATIONS

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ABSTRACT A search for λ Bootis stars in two OB associations (Orion and Lacerta OB1) has been carried out. One clear example of a ZAMS λ Bootis star has been discovered in Orion OB1. Both Orion OB1 and Lacerta OB1 contain, as well, a number of mildly metal-weak A-stars which may be λ Bootis stars in-the-making.

INTRODUCTION

The λ Bootis stars are a class of apparently metal poor, presumably population I, A-type stars. These rare stars (less than 20 to date have been unambiguously identified in the literature) present a considerable challenge to our theoretical understanding of stellar atmospheres. Spectroscopic work by Gray (1988) indicated that most of the known λ Bootis stars are ZAMS objects. This implies that the λ Bootis phenomenon may be related to a transitory phase in the evolution of the star shortly after it arrives on the main sequence (see also Charbonneau 1991). This observation suggests that λ Bootis stars should occur in young clusters and associations, but be absent in clusters of such an age that the A-stars are well-advanced in their main-sequence life.

OBSERVATIONS AND RESULTS

As a first step in testing this hypothesis, we have

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obtained, using the 2.3 meter telescope of Steward Observatory, high S/N CCD spectra of 50 A-type stars (many never before studied with slit spectrograms) in two OB associations (Orion OB1 and Lacerta OB1). These stars have been classified on the MK system, and most appear to be normal. However, four are Am stars, one is an Ap star, two are shell stars (see fig 1), and one (BD 39-4926, well-known in the literature, and probably a non-member) is a proto-planetary nebula.

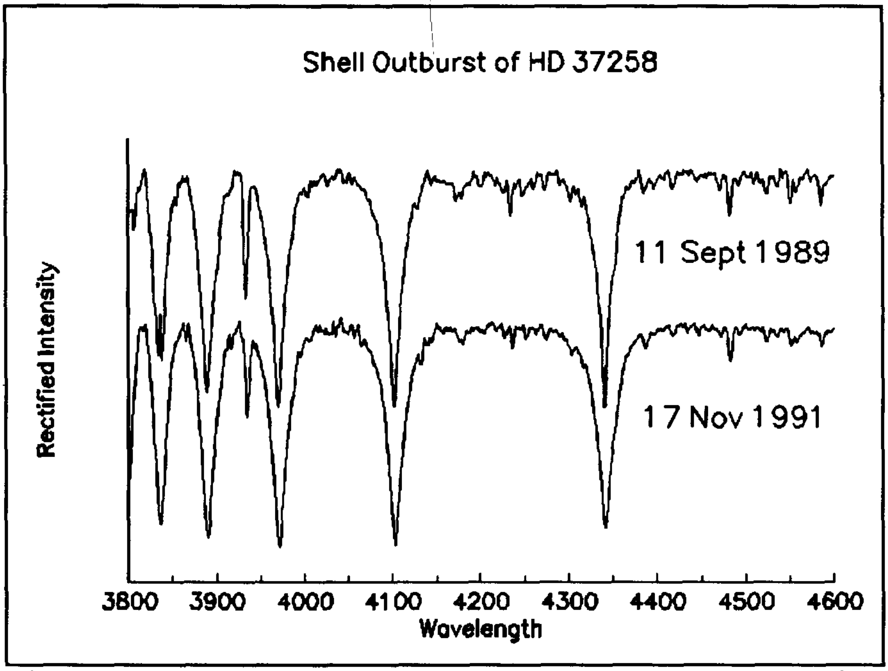

Figure 1: Two spectra of HD 37258, a member of Orion OB1 in the process of a shell outburst (11 Sept 1989) and in a quiescent stage (17 Nov 1991).

Of most interest to this survey is the discovery of one clear example of a λ Bootis star, HDE 290799, classified A2 Vb λ Boo PHL (see fig 2). The apparent magnitude of HDE 290799 places it directly on the ZAMS of the Orion OB1 association and it is listed by Warren and Hesser (1977) as a member. Indeed, HDE 290799 is one of the few truly ZAMS stars in this survey. Most others lie above the main sequence and

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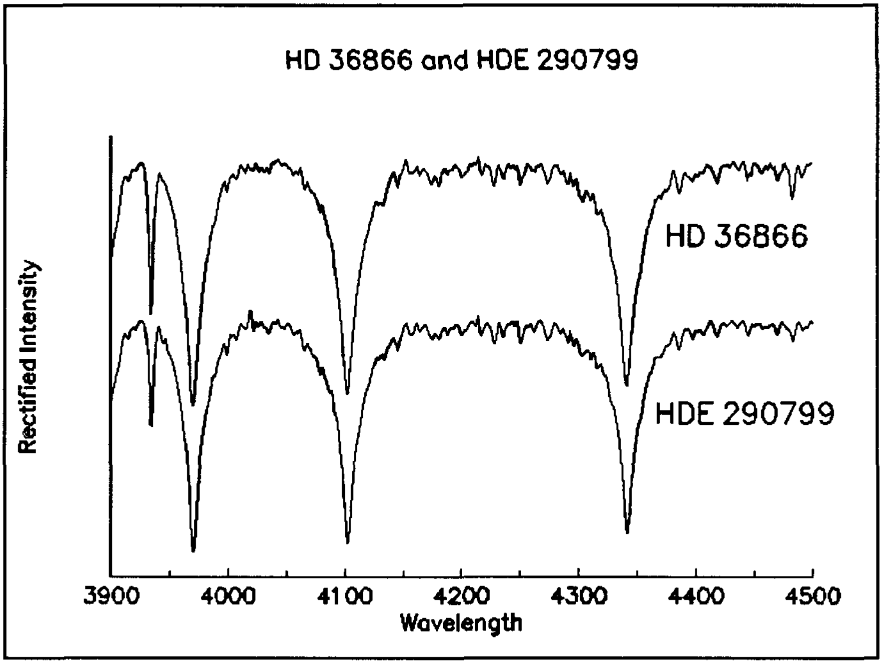

Figure 2: HDE 290799, the λ Bootis star discovered in Orion OB1 compared with HD 36866, an A2 Va star in the same association. The λ Bootis star can be distinguished from the normal star by the weakness of the Mg II λ4481 line, the discrepancy between the hydrogen-line-core spectral type (A6) and the metallic-line type (A2) - which implies that the star is metal-weak, and the slightly peculiar hydrogen-line profiles. HDE 290799 also has photometric colors similar to those of other λ Bootis stars.

are presumably still contracting to the main sequence.

Also of interest are nine stars (comprising members of both associations) which appear to be slightly metal-weak, but because the Mg II 4481 line is not particulary weak, do not seem otherwise to fall into the λ Bootis category. These stars (for the most part early A-type stars) appear to be metal weak because the metallic line spectrum is slightly weak for the Ca II K-line type. That this is a signature of metal-weakness in the early A-type stars is confirmed in figure 3 by means of synthetic spectra. These mildly metal-weak stars may be λ Bootis stars in-the-

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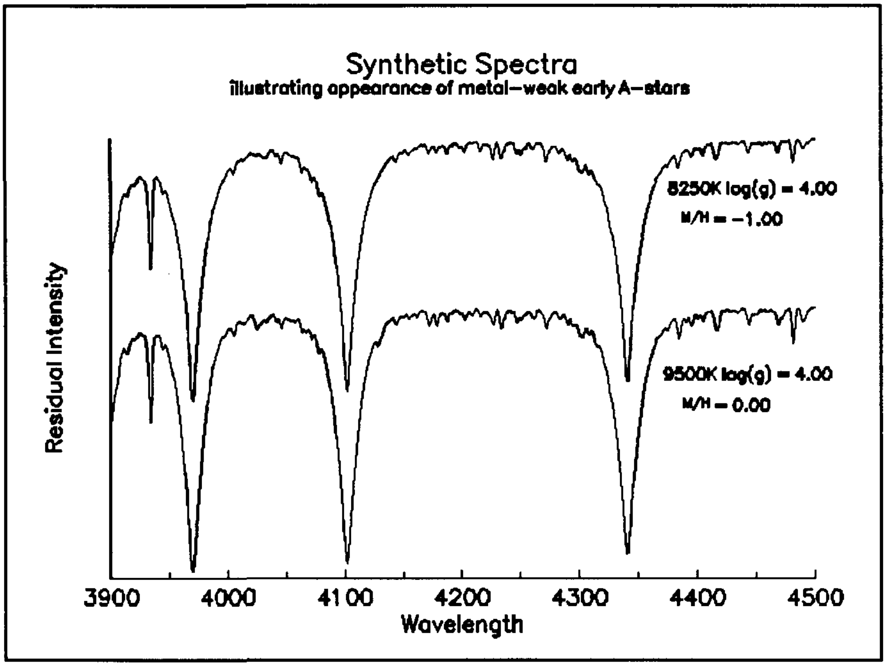

Figure 3: A number of slightly metal-weak stars have been found in the two OB associations. These metal-weak stars can be recognized by: 1) A K-line type which is slightly later than the metallic-line type, especially considering the metal lines longward of Hγ, and 2) an apparent weakness of the Mn I λ4030 blend. That these features are a signature of metal-weakness in the early A-type stars can be confirmed by spectral synthesis. Presented here are two synthetic spectra (computed by the program SPECTRUM; cf. Gray 1992), one with solar metallicities, the other with [M/H] = -1.00. Both have similar K-line strengths, and the two criteria mentioned above can be seen clearly in the metal-weak spectrum.

making, as most of them have not yet arrived on the main-sequence.

It is useful to mention that the presence of slightly metal-weak stars in young clusters and associations has been noted before. An example is HD 224964, a member of the Blanco 1 young cluster. This star was classified by Gray and Garrison (1989) as A3 Va^{-} (metal weak). We also note that Slettebak (1963) and Abt and Cardona (1983) discovered two λ Bootis stars that are secondaries in physical visual systems with B5 V and O9.5 III primaries respectively. We have not had a chance to confirm these two classifications.

The identification of this single λ Bootis star and the presence of a number of mildly metal-weak stars in two OB associations appears to strengthen the hypothesis that the λ Bootis phenomenon can be associated with an episode shortly after (or before) the star has arrived on the ZAMS. However, the work of Corbally and Gray (1992) on high galactic-latitude A-type stars suggests that the λ Bootis phenomenon may also occur in quite a different context.

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DISCUSSION (Gray and Corbally)

GERBALDI: It is obvious fron these poster papers that λ Boo candidates can only be detected by skilled astronomers in the domain of spectral classification with photographic plates. How can these classification criteria be adapted to the digitized spectra obtained with a CCD?

GRAY: The λ Boo stars are not so difficult to detect provided one knows what to look for, and one has high-quality spectra. This applies both to photographic spectra and to digital spectra. Indeed, one must be especially certain, when working with CCD spectra, to obtain a high enough S/N to match the large amount of information in a well-widened, well-exposed photographic spectrogram. This means that a S/N of at least 100 should be the goal for precise MK spectral classification of CCD spectra. Apart from that, the spectral criteria used for photographic and digital spectra are the same, and one must also be certain to have plenty of good MK standards taken with the same spectrograph/detector at hand.

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