# THE OCCURRENCE OF ABNORMAL STARS IN OPEN CLUSTERS

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## ABSTRACT

Morgan, Keenan, and others have found that low dispersions (80-130 Å $mm^{-1}$) are ideal for obtaining spectral types and luminosity classes, especially for early-type stars. This is because at those dispersions certain blends are unresolved and remain useful, the hydrogen line wings are seen most clearly, and differences in rotational velocities are not so important. Such dispersions are also ideal or adequate for detecting some peculiarities, such as Am and Be spectra and some extreme Ap spectra, but they are inadequate for detecting abnormalities involving weak lines (as in Ap(Hg, Mn) stars) and line profiles (such as in shell spectra).

We made a new search for Ap, Am, Be, shell, and other peculiarities among the 661 brightest stars in 14 open clusters and associations (Orion Nebula, Orion OB1, $\alpha$ Persei, Lacerta OB1, IC 2602, IC 4665, Pleiades, M39, M34, NGC 2516, NGC 6633, NGC 6475, Ursa Major stream, and Coma), using very wide (1.2 mm) spectra of two dispersions (39 and 128 Å $mm^{-1}$) for each star. The classifications were done mostly with Hugo Levato and W. W. Morgan. These classifications show the following results:

1. There are no Ap stars in the youngest cluster and the frequency of occurrence increases with time, although all slow rotators do not become Ap stars. The minimum age of Ap(Si) stars is $10^6$ yr and of Ap(Hg, Mn) stars is $10^7$ yr. Field Ap stars have the same frequences as those in the older clusters.

2. Am stars occur in essentially all clusters so the time of formation is less than $10^6$ yr, but the frequency of occurrence

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differs drastically from cluster to cluster, probably due to differing frequencies of binaries. Field and cluster Am stars have the same mean frequencies of occurrence.

3. The rotational velocities of Ap and Am stars decrease with time, varying inversely as the square root and fourth root of their ages, respectively. These are probably the rates of magnetic braking and tidal braking in binaries, respectively.

4. The youngest stars have abnormally broad hydrogen lines. The occurrence of such stars varies inversely as their ages and probably is a characteristics of stars on the ZAMS.

5. The occurrence of shell spectra and Be spectra does not vary with age.

The full article has been submitted to the Astrophys. J. for publication.

DISCUSSION

Mendoza: What is the frequency of Ap stars in the Pleiades and in the Hyades?

Abt: As I recall, there are three Ap stars and four Am stars in the Pleiades. We did not reobserve the Hyades.

Gratton: I was a bit surprised by your correlation between v sin i and age. I would have expected an envelope curve rather than a relation between the average value of v sin i and age.

Abt: It is an envelope because of the inclination factor. The small numbers of Ap stars give deceptive results; in the case of the more numerous Am stars, the envelope aspect is more obvious.

Gerbaldi: You present an observational relation between v sin i and the logarithm of the age for Ap-Si stars and you attribute this to magnetic braking. We know that during its life on the main sequence, a star's rotational velocity decreases because of evolutionary effects. Can you estimate the importance of this effect on your relation?

Abt: The reduction in velocity for the Ap stars is by a factor of about 5; the evolutionary reduction for the normal stars is about 25-50%.

Divan: The rotational velocity of Ap stars is decreasing when age is increasing. What is the situation for non-Ap stars?

Abt: The normal stars show very little variation with age, and that variation is partly masked by the differences between individual clusters.

Code: You pointed out that the Be phenomena must set in early. Is there any problem with Be stars being required to live too long since they are also in the oldest clusters?

Abt: They are observed only in those clusters in which stars of those luminosities are still on the main sequence.

Walborn: Could the Be stars still be contracting to the main sequence in your youngest cluster but have evolved off the main sequence in the oldest? While apparently most helium-rich B stars have sharp lines, the three known in the Orion association have broad lines and are evidently rapid rotators. Recently Borra and Landstreet have discovered magnetic fields in a number of these

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stars. There may be a relation to the Ap rotation/age dependence you have found.

Abt: The Be stars are already on the main sequence in the youngest clusters, and still on the main sequence in the oldest clusters. Sidney Carne Wolff has also done similar work in clusters and finds the same relation between v sin i and age for Ap(Si) stars.

Jaschek: Besides the classes of peculiar stars you described, have you found any new types of spectra?

Abt: Yes, some stars with weak K lines as their only peculiarities, a new class of shell stars, and a few strange Ap stars.

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