Stellar Rotation
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André Maeder & Philippe Eenens, eds.

DISCUSSION: Observations of Rotating Stars

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1. Highlights

Broadly speaking, today's contributions fall into one of two groups, low mass stars or high mass stars. Generalising again, those participants discussing low mass stars are concerned with tracing and understanding the evolution of stellar angular momentum from the pre-main-sequence phase through the main-sequence and into advanced stages of evolution such as AGB and red giants (Mathieu, Stauffer and Medeiros). In this respect, they are much more advanced in understanding the importance and impact of rotation on stellar evolution than the massive star community.

For massive stars, talks by Collins and Howarth highlighted the problem of relating line-widths to actual rotational velocities, emphasising that the quantity representing a measure of the line-width often referred to as $v \sin i$ may not be an accurate estimate of the product of the stellar equatorial rotational velocity v_e and the sine of the inclination angle of the rotation axis ($\sin i$). For fast rotators in particular, a straightforward interpretation of $v \sin i$ as representing $v_e \sin i$ may well lead to a significant underestimate of v_e implying that fast rotators may well be rotating closer to critical velocity than might otherwise be assumed, with important implications for understanding mass-loss for example.

Concerning the actual distribution of $v \sin i$ for massive stars, Gies presented some new, albeit preliminary, results for stars in open clusters, finding some systematic differences between clusters. While the interpretation of these results is not yet clear such studies are of great importance since, in contrast to the situation in the low mass domain, relatively little is known about the evolution of stellar angular momentum for massive stars. While there is certainly information concerning distributions by spectral type, what is conspicuous by its absence is information on $v \sin i$ distributions by evolutionary state (luminosity class).

2. Rotation in Field and Cluster Stars

Continuing the theme of $v \sin i$ distributions for massive stars, it was pointed out by both Gies and Lennon (citing work by Wolff and Abt) that the distribution of $v \sin i$ for bright association and field B-type stars is strongly bimodal, there being a surfeit of low-$v \sin i$ stars compared to what one would expect if rotational axes are randomly oriented. Collins asked the question of whether or not the rotational axes of stars in a cluster might be aligned, perhaps explaining the fact that Gies finds significant differences in mean $v \sin i$ values for some open clusters. Contributions on this point by Gies, Mathieu, Abt, Levato, Lennon

and Strom indicated that while this might well explain the observations there was good evidence from observations of Be stars in open clusters in the Magellanic Clouds that their axes are randomly distributed ($\sin i$ being measured from the morphology of the Be stars' H-α emission profiles).

3. Be Stars and Surface Abundances

In response to a suggestion by Lennon, referring to posters by Frémat, that the composition of a number of Galactic Be stars appears to be rather normal, Maeder asked if the Be-stars display any evidence of nitrogen enrichment. Zorec replied that carbon appeared to be depleted in their sample, however Meynet pointed out that this should also be accompanied by a nitrogen enrichment if the anomaly was due to rotationally induced mixing. Frémat commented that it was difficult to say if nitrogen was enhanced in their work, although Walborn suggested that there was perhaps one object in their sample displaying strong nitrogen lines. Townsend asked if gravity-darkening was taken into account in the analysis since this might complicate the abundance determinations, however Zorec replied that this was indeed included in their work and in any case the ratio $\omega/\omega_{\rm crit}$ is approximately 0.8 for their most extreme objects. However Owocki reminded us that when a star is rotating at close to critical ($\omega_{\rm crit}$) velocity the limb contributes very little to the observed line profile and thus it is actually difficult to tell how close to critical velocity an object might be rotating. On this cautionary note the discussion was closed.

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