Radial and Rotational Velocities in NGC 2264

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Radial velocity (RV) measurements are a powerful tool for investigating kinematic substructure in young star forming regions. We present RV's for 610 stars in the young nearby star forming region NGC2264. These cover a magnitude range of 12.5 < I < 18.5 and have been derived from R=16200 spectra obtained using the Giraffe spectrograph at the VLT, Chile. We explore the likelihood of kinematic substructure within the cluster and compare this with the already-known spatial sub-groups. The distribution of RVs is non-Gaussian, with several separate RV sub-groups. We also present projected equatorial velocities for stars in NGC2264.

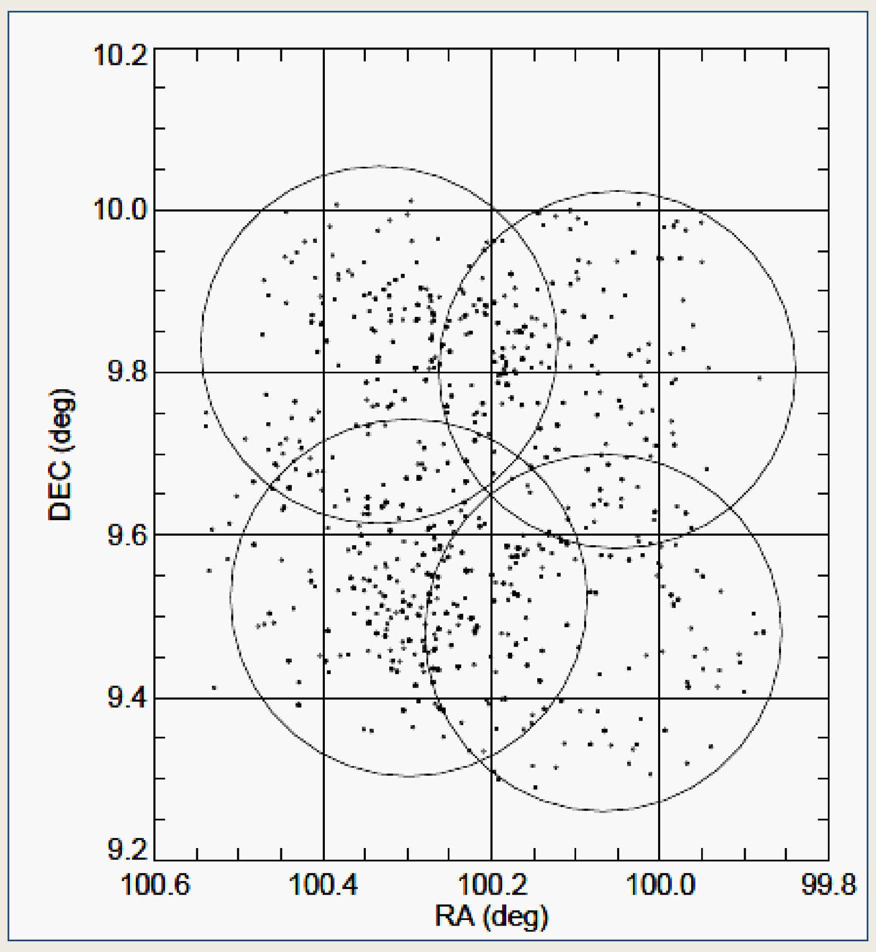


Figure 1 – Plot of the positions of the four fields and targets used in our observations.

NGC 2264

NGC 2264 is a young, nearby, well-studied cluster. With a mean age of 3Myr, distance of 760 pc (Sung et al. (1997)) and low foreground extinction, it is a suitable area to study star formation timescales and scenarios. Unlike many other nearby young clusters, several spatial subgroups have already been determined (Teixeira et al. (2003)) which adds interest in performing star formation studies on this cluster. A spread of stellar ages is also evident within the cluster, which could indicate separate star formation events occurring several Myrs apart.

Observations

Our observations included 4 fields with 25' diameter each (displayed in figure 1), and each observed with bright (12.5 < I < 15.5) and faint (15.5 < I < 18.5) configurations. >200 targets were observed several times which can be used to estimate measurement uncertainties in RV and *vsini*.

The NGC 2264 open cluster is situated within the Monoceros OB1 Association and includes several nebulae and spatial sub-clusters situated within the cloud. The cone nebula and fox fur nebula are displayed in figure 2. Also within the cloud is the massive, O-type star, S Mon. The cluster is positioned in front of a giant dust cloud which makes distinguishing the cluster members from background stars more straightforward.

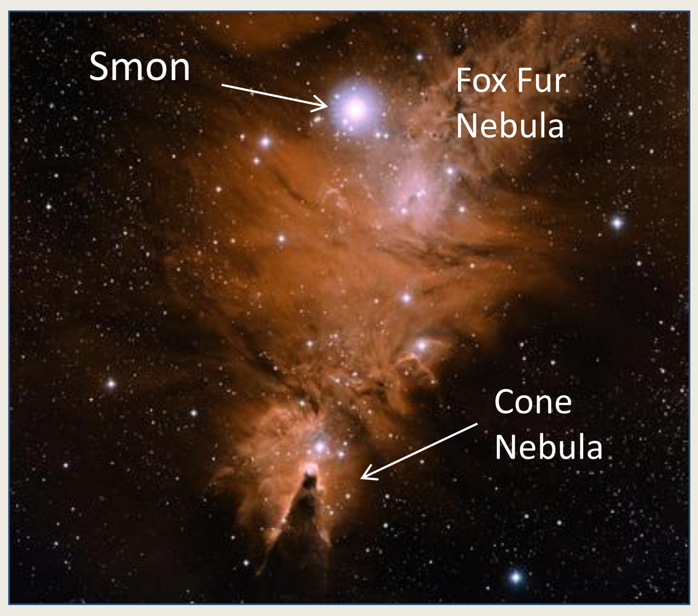


Figure 2 – An image of NGC 2264 (credit:ESO)

Radial Velocities

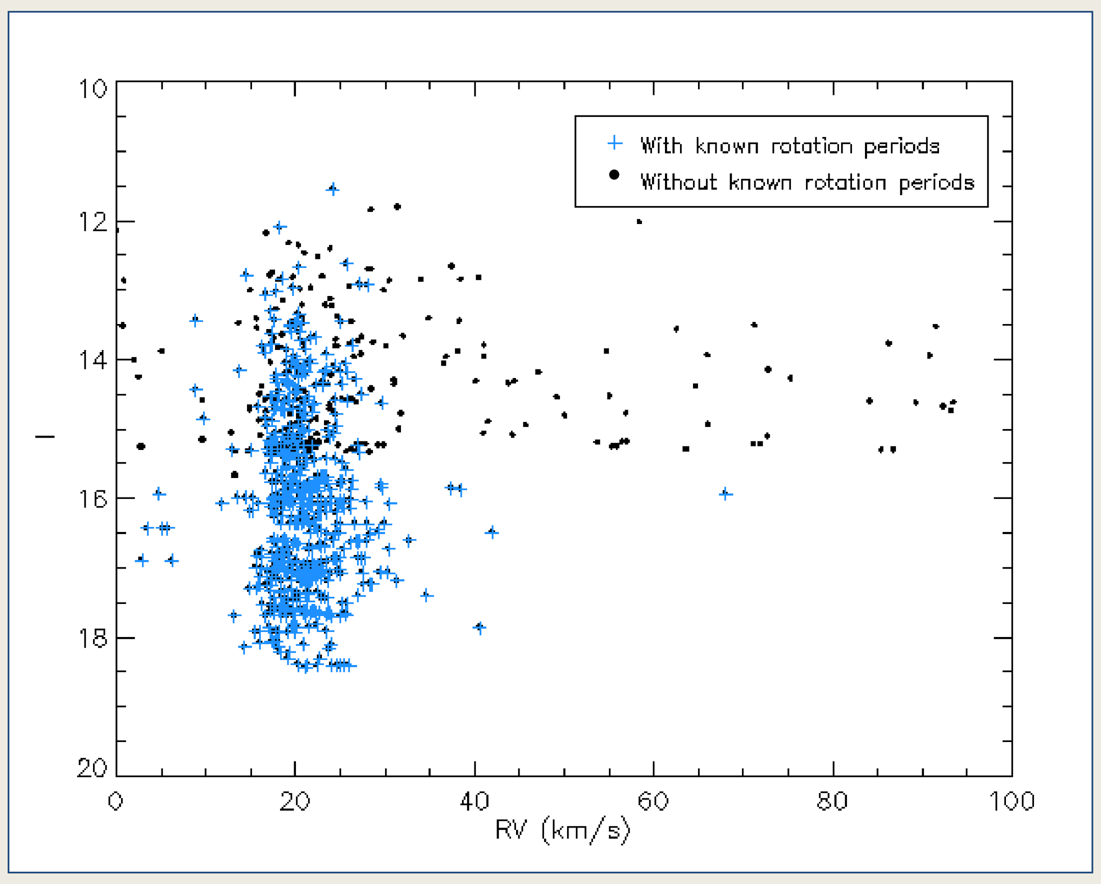
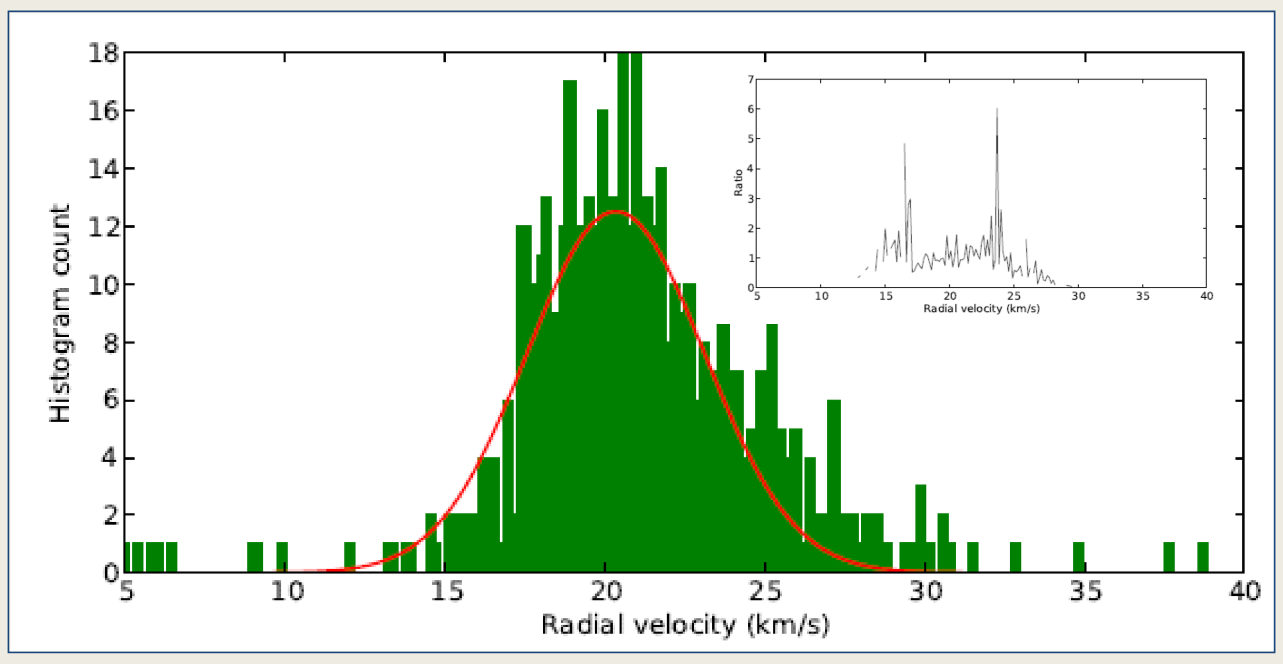


Figure 3 (left) I magnitude against RV for stars with and without rotation periods.

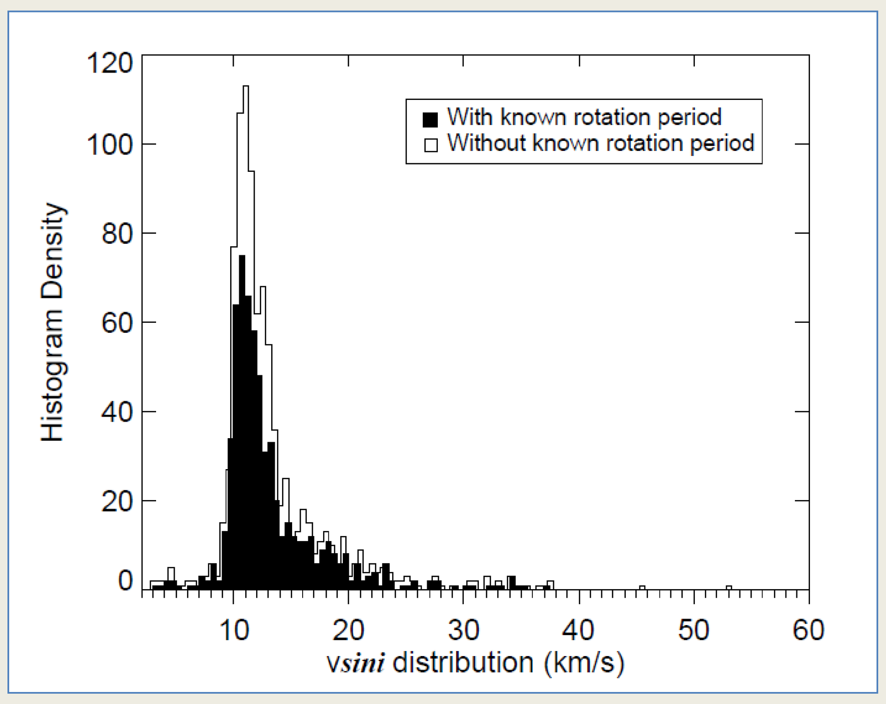
Figure 4 (below) Distribution of RVs of stars with known rotation periods only. The inset is a ratio plot of the distribution(green)/ Gaussian(red).



Both RV and *vsini* distributions are used to investigate star formation to detect kinematic sub-structure within the cluster. Here we present RV's for 610 stars, 368 of which have known rotation periods and empirically determined measurement errors (from repeated data) of 0.41km/s, approximately double the precision of a previous similar study by Fűrész et al. (2006). From figure 3 the broad spread in RVs is most likely due to contamination from non-members. Since rotation periods are more likely to be gained for pre-main sequence stars, those with known rotation periods were used as membership criteria.

Figure 4 shows the distribution of RVs with rotation periods. Despite using the targets with known rotation periods, the spread of RVs was still larger than the measurement error. Assuming spatial structure in the cluster – we would expect a non-Gaussian distribution of RVs. Although no clear spatial subgroups are present in figure 4, the Gaussian is much broader than the uncertainties showing a true spread in RV's. The figure 4 inset is a ratio plot of the RV distribution divided by the best fitting Gaussian, further showing that the distribution is non-Gaussian which could indicate kinematic substructure.

Rotational Velocities



The *vsini*'s were determined by cross-correlating the stellar spectra against a template of similar spectral type which had been broadened by a kernel to a known *vsini*. The *vsini*'s were interpolated from relationship between the width and *vsini* of the template spectra.

Splitting the RVs into nine equal groups over the range 12 < RV < 30, the mean *vsini* was calculated per RV group and plotted along with the standard deviation on figure 6. Although when taking into account the error bars, the mean *vsini* in each RV group *could* be nearly constant, the distribution more likely shows the presence of unresolved binaries which would have a broader cross-correlation function and therefore, would have a high measured *vsini* .

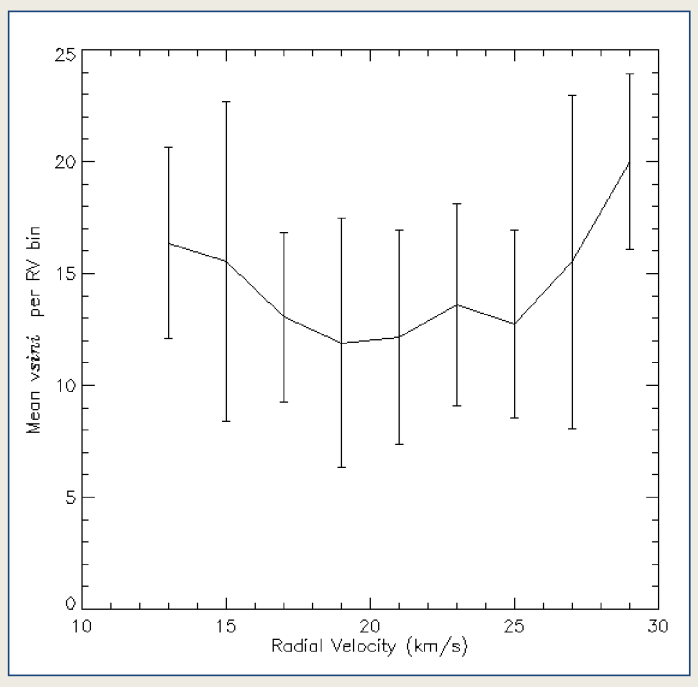
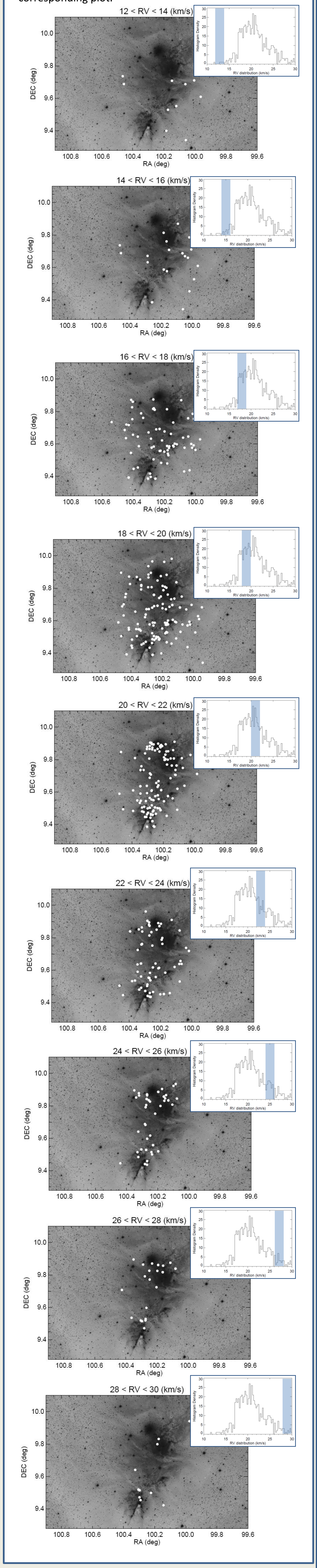


Figure 5 (above) The distribution of *vsini* for members of NGC2264, centred at approximately 12km/s with very few slow rotators and a tail towards higher *vsini*. Each bin is 0.5 km/s. There is no clear bimodality of evidence of substructure revealed by the distribution.

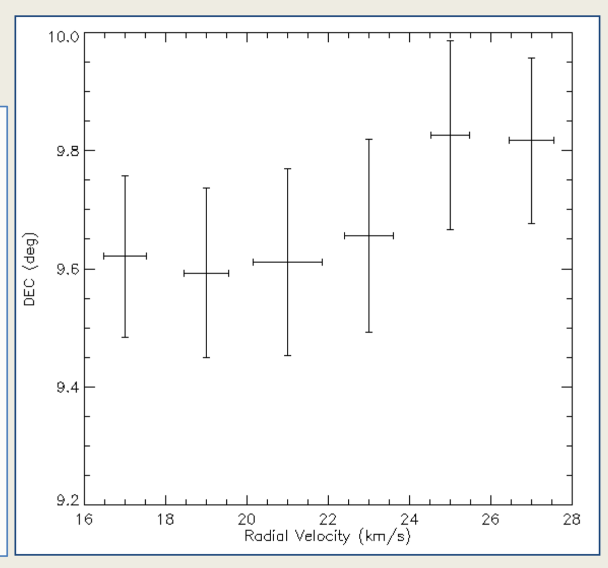
Figure 6 (above) The mean *vsini* per velocity bin. The errors correspond to the standard deviation of the *vsini*'s per bin.

Figure 7 – Positions of stars in nine equal RV bins plotted over a DSS image of the cluster. The highlighted area of the histogram shows the RVs which are displayed in the corresponding plot.



Evidence of Substructure?

Splitting the RV's into nine equal velocity bins reveals possible substructure within the cluster. The targets with higher RVs appear to be distributed into 2 clumps , the first just below Smon, and the second near to the cone nebula. The lower RVs are situated more randomly and away from these areas (see figure 7). The (possible) sub cluster below Smon is primarily occupied with stars of 18 < RV < 28. Very few stars with RV < 18km/s lie within this area. This is emphasised in figure 8 (right) which shows an increase in RV with declination, a similar (but less prominent) result to that found by Fűrész et al. (2006).



References

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