ROTATION OF LATE TYPE STARS IN YOUNG CLUSTERS

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ABSTRACT. We present here results of B and V-band photometry of 35 late type dwarf stars in the young open clusters: Pleiades, α Persei, and Coma Berenices obtained at Catania from 1992 to 1996. Periodicity in the light variations was searched applying the CLEAN algorithm to the periodogram analysis.
We have detected rotation periods for 15 out of the 16 observed Pleiades, 10 out of the 15 α Persei and 3 out of the 4 Coma. The periods range from about 6 to 10 hours for α Persei, with the exception of AP 110, from about 7 hours to 4 days for the Pleiades and from 4.5 to 10 days for the Coma stars. Statistically the trend of rotation periods gives a clear evidence, even for the present limited sample of G-K stars, of the rotation decay with age. We argue that the spread around the mean period for each cluster could be the remnant of the initial angular momentum distribution.
We noticed also a tendency for faster rotators to show light curve of larger amplitude, indicating a stronger activity also at photospheric level.

1. Introduction

The estimate of rotation periods of late F, G and K dwarfs in young open clusters through photometric monitoring is fundamental for studying the angular momentum evolution of solar–type stars. Low-amplitude periodic light variations are ascribed to the modulation by uneven starspot distribution.

Systematic obseravtions devoted to the determination of rotation periods from the analysis of light curves in young late type stars have been performed since 1991 at Catania Astrophysical Observatory, partecipating also to coordinate campaigns (Prosser et al., 1993; Bouvier et al., 1997). Here we present preliminary results of a B and V-band photometric monitoring of 35 late-type dwarfs in the young open clusters Pleiades (16 stars), α Persei (15 stars) and Coma Berenices (4 stars). The ages of the clusters spread from 50 Myr of α Per to 80 Myr of Pleiades (Mermillod, 1981), and 400–500 Myr of Coma Berenices (Friel and Boesgard, 1992)

Two stars in α Per (He 628 and He 1150) and one in the Pleiades region (HII 752), considered non-members of the clusters, were initially included as comparison stars. The K1 weak T Tauri star WTT 032641+2420, in the Taurus-Auriga complex with an age of 25 Myr (Walter et al., 1988), was also observed.

2. Observations and analysis

Observations were obtained at *M.G. Fracastoro* observing station (Serra La Nave,Mt. Etna) of the Catania Astrophysical Observatory from 1992 to 1996 with the 91 cm telescope. A photon-counting cooled photometer equipped with an EMI 9789QA photomultiplier was employed.

Tab. 1 - Period determinations of stars observed at SLN

Star	V (mag)	B–V	$v \sin i$ Km/s	Period	Ampl. $\Delta V(mag)$	Remarks
Pleiades						
HII 250	10.68	0.68	7	$0^d.843$:	0.06	
HII 253	10.66	0.68	37	$1^d.721$	0.12	
HII 314	10.56	0.64	38	$1^d.491$	0.12	SB?
HII 345	11.57	0.84	19	$0^d.682$	0.065	
HII 708	10.12	0.60	46	$0^d.294$:	0.05	
HII 727	9.70	0.55	50	$0^d.532$	0.06	
HII 738	12.26	1.17	50	$1^d.460$	0.085	$(B–V)_0 = 0.81$
HII 739	9.56	0.62	13	$0^h.906$:	0.04	
HII 882	12.66	1.07	65	$0^d.604$	0.10	Hα em.
HII 885	12.05	1.01	7.5	$0^d.435$:	0.055	
HII 975	10.56	0.81	< 5	$4^d.082$:	0.05	bin.
HII 1032	11.34	0.86	36	$1^d.299$	0.10	
HII 1514	10.48	0.64	15	$3^d.333$	0.105	
α **Persei**						
He 684	10.54	0.57	71	$0^d.388$	0.065	
He 696	11.61	0.76	10	$0^d.269$	0.08	
He 699	11.27	0.71	90	$0^d.342$:	0.06	
He 709	10.95	0.68	59	$0^d.231$	0.08	
He 935	10.05	0.62	78	$0^d.275$	0.05	
AP 104	12.06	0.78	< 10	$0^d.409$:	0.08	
AP 110	12.27	0.92	< 10	$5^d.519$	0.08	Hα abs.
AP 118	11.98	0.81	160	$0^d.319$	0.16	Hα broad em.
AP 225	11.83	0.78	138	$0^d.325$	0.17	Hα em.
Coma						
T 203	10.81	0.895	—	$9^d.605$:	0.06	
T 213	10.51	0.773	—	$4^d.7$::	0.04	
T 219	11.18	0.82	—	—	< 0.04	
T 221	10.38	0.834	—	$10^d.020$:	0.05	
Field Stars						
HII 752	11.1	1.5	—	$24^d.814$	0.15	non-member
He 628	11.19	0.65	53	$2^d.676$:	0.045	non-member
He 1150	10.1	0.62	—	$5^d.64$	0.08	non-member
WTT032641	12.0	0.9	> 75	$0^d.5357$	0.185	weak T Tau

We derived periods of light variations by means of a periodogram analysis (Scargle 1982) on the magnitude differences, (*var–comp*), in the B and V-bands. The highest

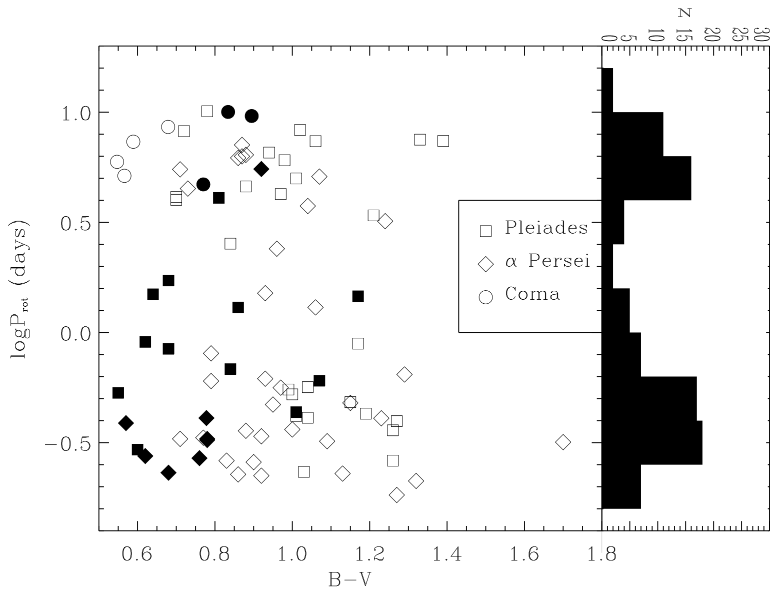

Fig. 1. *Left)* Rotation periods versus B–V color indices for the three investigated clusters. Filled symbols represent periods derived in the present work.
Right) Histogram of the period statistical frequencies for stars in the three clusters. A bimodal behavior is apparent.

peak in the power spectrum was selected applying the CLEAN deconvolution algorithm (Roberts et al. 1986). It allowed us to reject aliases generated by incompleteness of the data sampling and by the finite time span of the observations.

We used also the phase dispersion minimization (PDM) method available on IRAF to check the CLEAN results, finding an excellent agreement between the two methods.

Table 1 lists the results of the period analysis for the stars together with relevant physical parameters and the observed $v \sin i$. The ΔV amplitude of the observed light curves is also given. The obtained periods range from 6 to 10 hours for α Persei cluster (with the exception of the slow rotator AP 110, for which we find a period of about 5.5 days), from 7 hours to 4 days for the Pleiades, while we have possible detection of periods from 5 to 10 days for three Coma members.

The field star HII 752, used during 1992 observations as a check star, was discovered to be variable and observations in subsequent years confirmed a variability with a period of 24.8 days. If it were a main sequence star its equatorial velocity would be less than 2 Km s^{-1}, while the wave amplitude of $0^m.15$ is typical of a very active object, like the giant components of RS CVn binaries. The rotation period would place HII 752 among the long-period RS CVn binaries.

More difficult is the interpretation of the periodic variations of the two G-type stars (He 628 and He 1150) observed in the α Per region, and given in literature as non-members. The derived periods are not too different from that of the slower rotators of the cluster (Allain et al., 1996) and this could imply a re-discussion about their membership.

The weak T Tauri star WTT 032641+2420 shows the larger wave amplitude ($0^m.185$) with a well estabilished period of 13.6 hours.

3. Results

The histograms of the period statistical frequencies and P_{rot} as a function of (B–V) for Pleiades and α Persei give clear evidence, even for our limited sample of G–K stars, of the rotation decay with age (α Persei: 50×10^7 years and $< P_{\rm rot} >= 0^d.3$; Pleiades: 80×10^7 years and $< P_{\rm rot} >= 1^d.1$). The spread around the mean periods would be a remnant of the initial angular momentum distribution (Catalano et al. 1988; Stauffer and Hartmann 1987).

The plot of rotation periods, derived in the present work and values taken from the literature, versus the B–V color indices of the stars belonging to the three clusters (see figure), shows no particular trend with the spectral type. However a separation of fast and slow rotators is apparent, so suggesting a bimodal behaviour both in the Pleiades and in α Per clusters, as observed for T Tau stars (Allain et al., 1996).

A quick analysis of light curves as a function of P_{rot} gives evidences for a mean trend of the amplitudes to increase with the increase of rotation velocity, confirming the increase of activity at photospheric level with the rotation rate. On the other hand the presence of large and small amplitudes among fast rotators could be due to both intrinsic effects and projection effects.

The present results represent a partial contribution to a more extended program on the angular momentum evolution from the earliest phases of the stellar evolution up to the main sequence.

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