ROTATION PERIODS AND ACTIVITY ON RED DWARFS

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ABSTRACT. Relation between duration of cycles of photospheric activity and stellar rotation are considered here for samples of dKe–dMe stars and compared with similar ones for solar-like stars. Fast and slowly rotating stars shown two sequences on the diagram. Cycle length of slowly rotating stars is close to solar and not depend on rotation, but red dwarfs with $P_{rot} < 5^d$ show tendency to insceasing of cycle time with faster rotation. Activity of fast rotating K and M dwarfs are more higher as well on photospheric level as coronal region.

Key words: Stars: stellar activity, magnetic cycle on red dwarfs.

1. Introduction

Magnetic activity on late-type dwarfs are manifested in different atmosphere layers through photospheric spots, chromospheric Ca II H and K emission lines and coronal X-ray fluxes. This type of activity reflects the processes of interaction between magnetic field, rotation and convective motions in subsurface convective zone and described for solar-like stars due to action of dynamo mechanism (Parker 1955). Studying of active processes on the bright F–K dwarfs are based on the long-term monitoring chromospheric Ca II H and K emission lines (Baliunas and Vaughan 1985). Research of these stars allow to find the relation between cyclical changes in H and K fluxes, rotational velocities and stellar ages. Rotational velocity of the main-sequence stars (MSS) with $B - V < 1$ is fitted well as $t^{-1/2}$ (Skumanich 1972, Rengarajan 1984).

2. Rotation and activity properties of red dwarfs

To study of magnetic activity nature on dKe-dMe stars we obtained long-term light curves using photographic archives and photometric data and found slow changes, suspected cyclical, in photospheric spottedness. Rotation–activity relation for late dwarfs with $0.4 < B - V < 1.9$ are represented on fig. 1. Data includes chromospheric active stars taken from so–called H–K project (Baliunas et al. 1995, Bruevich et al. 2001) and active red dwarfs (Bondar' 1996, 2001; Alekseev 2000).

According to the diagram P_{rot} vs. $B - V$, the rotation period of the MSS increases steady towards the later spectral classes. Most of dKe–dMe stars and few F–G dwarfs are the fast rotating objects with $P_{rot} < 10^d$. This stellar group contains young stars and independently of spectral classes they have the similar rotation periods before they reach the main sequence (NS) stage. Then rotational velocity drops in many times, especialy for late-type stars, and P_{rot} increases smoothly along the MS as a function of stellar age.

The plot $\log L_{bol}$ vs. P_{rot} shows the obvious relation between total luminosity and rotation for F–K MSS. According this diagram the upper value of rotation period for MSS is 2 days. The lower luminosity dKe–dMe stars show any relation between the considered values. Most of red dwarfs have $P_{rot} < 6^d$. Surface spottedness of red dwarfs is changed with time and that has produced their long-term light variations. Typical time of such variations is about one or some decades and comparable at present with their observational spans. In this sence P_{cyc} is uncertain value for K–M dwarfs and should be considered as suggested. Diagrams P_{cyc} vs P_{rot} and A_{cyc} vs. $\log P_{cyc}$ show that fast rotating stars have more strength and long spot cycles than it defined for stars with $P_{rot} > 10^d$, which cycles are not exceed of 18 years. Both fast rotation and large cycle length represent observational evidences that magnetic activity on the lower luminosity red dwarfs and on solar-like stars are different and produced by different dynamo mechanism. It seems that period of 5 or 6 days is the critical for existence of cyclical stellar activity. According diagram $\log L_x/l_{bol}$ - P_{rot} stars with chaotic chromospheric activity are located in region, where rotation period is less than 6^d and they absent at all when $P_{rot} > 20^d$.

The photospheric activity level of fast rotating dKe stars is higher than dMe stars. These stars show large amplitude of long-term variations and long cycles. They are the most active among late–type dwarfs. The same conclution follows from the plot $\log L_x/L_{bol}$ - P_{rot}. The fast rotation of K dwarfs leads to their high coronal fluxes. The other observational fact is

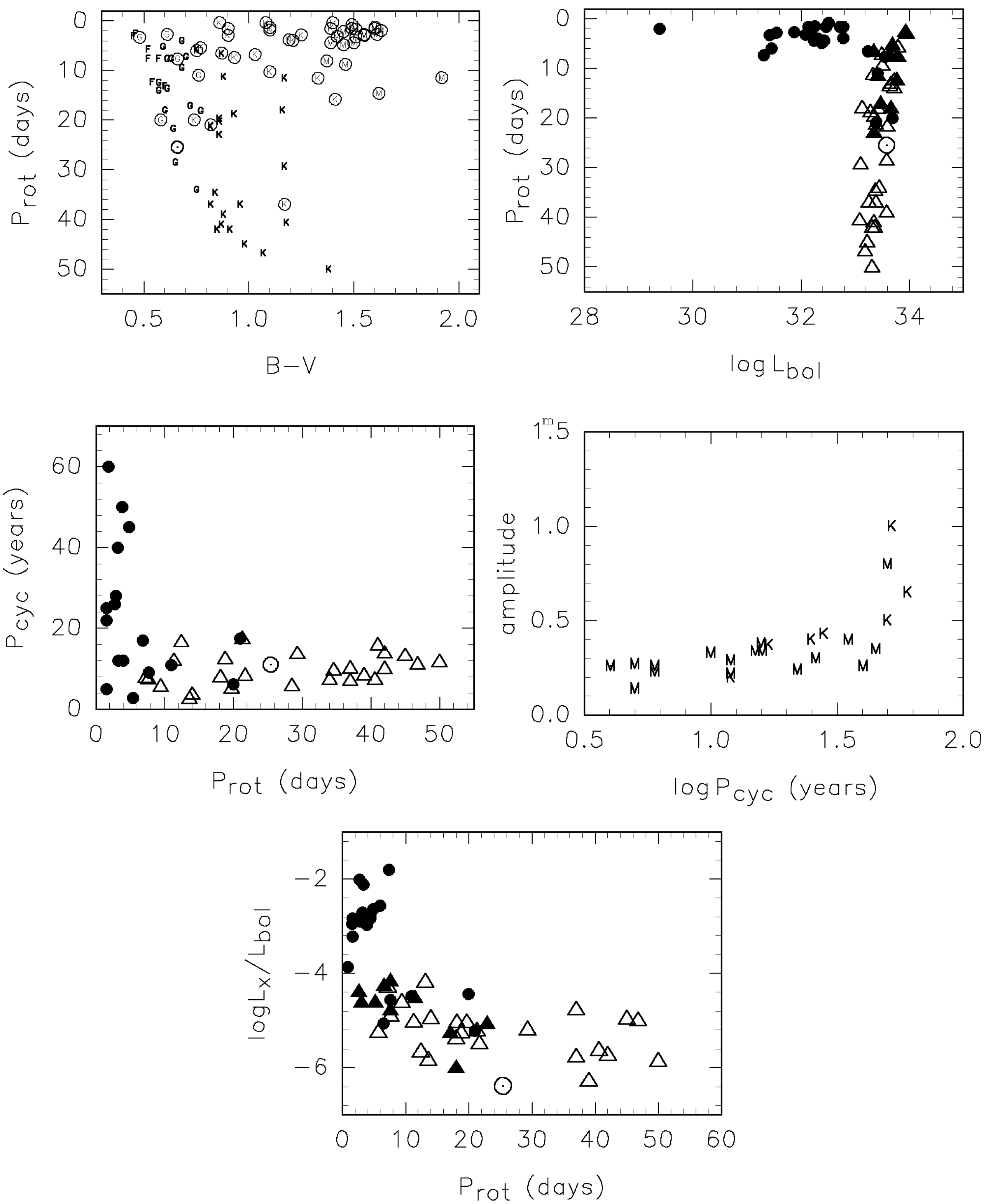

Figure 1: Rotation-activity relations for F–M dwarfs. The filled circles indicate spotted dKe–dMe stars. Chromospheric active F–K dwarfs are represented by open triangles (cyclical changes) and by filled triangles (chaotic changes). Special symbol signs the Sun.

that some chromospheric active stars with $P_{rot} < 20^d$ and chaotic changes in H and K fluxes have the higher ratio L_x/L_{bol} than slow rotating stars.

3. Summary

Rotation period is not one but a dominant factor responsible for a development of cyclical stellar activity and its level. Fast and slowly rotating stars are separated on two sequences on the rotation-activity diagrams when $P_{rot} < 6^d$. This value appears the critical to occur the different activity properties in low and fast rotating late-type dwarfs and may be a different dynamo mechanism. Cycle length of slow rotating stars with $P_{rot} > 20^d$ is not longer than 18 years that are close to the solar cycle. Chaotic chromospheric activity starts occur on several stars when $6^d < P_{rot} < 20^d$. When rotation period of chromospheric active stars drops to 6^d then activity character becomes chaotic only. If the spotted activity of fast rotating K and M dwarfs is cyclical these stars show tendency to insceasing cycle length twith rotation period. Among active F–M dwarfs the fast rotating dKe stars appear the highst activity level as well on photosphere as in a coronal region.

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