Activity in Single Late Giants: the Present Status of the Problem

Renada K. Konstantinova-Antova
Institute of Astronomy - BAS, Sofia, Bulgaria
antovi@astro.bas.bg

Abstract

The evolutionary status and rotation of active and fast rotating low and intermediate mass giants are considered.

The most active low mass giants deviate significantly from the law of rotational distributions for their mass (Pasquini et al., 2000). Most of the intermediate mass giants, however, exhibit moderate activity level and do not deviate from the relevant distribution in a significant degree. An explanation of this fact could be a specific evolution of the convective envelope in some low mass stars leading to the observed higher rotational velocities and activity levels. The different activity behaviour, found in the intermediate mass giants needs a further study.

The magnetic activity is presented in the cool half of the H–R diagram in stars at different evolutionary stages – pre Main Sequence (MS) stars, MS stars and evolved ones. In spite of their evolutionary stage it is believed that the dynamo powered by the convection and catalyzed by the stellar rotation is the reason for this activity.

The stronger activity of the RS CVn systems and FK Com type stars attracted the interest of the astronomers. The study of the single active late giants began later, approximately 10 years ago. Different signatures for their activity are observed in the electromagnetic spectrum. Recently, a scanty group of such stars was formed (Fekel&Balachandran, 1993) and this group of low and intermediate mass giants grows up slowly.

The post MS evolution of one approximately $3M_\odot$ star goes through different stages. As the star evolves after the MS, it still retains its rotation during a brief period, but begins to develop a convective envelope. A rapid bracking occurs during the crossing the Hertzsprung gap to the base of the red giant branch (RGB). At the base of the RGB the star is already slowly rotating one. As it is known from the study of a large sample late giants (De Medeiros et al., 1996) only 5% of these stars have Vsini values larger than 3 km/s.

Simon&Drake (1989) proposed a hypothesis to explain how single late giants become active. According to them the late giants acquire magnetic activity due to rapid spin–up when their convection zones advance the faster rotating stellar interiors. The authors supposed, it happens at the base of the RGB and believed that every small and intermediate mass giant becomes active at this stage. The small number active single giants was explained by assuming that the activity phase is a brief episode. They supposed magnetic bracking to spin–down rotation of the star for a short time.

Recent works (Schroeder et al., 1998; Duppree et al., 1999; De Medeiros et al., 1999) and the Hipparcos parallaxes available for most of the known objects of this type revealed that these giants are fairly evolved ones. Fig. 1 presents the evolutionary stage for most of these stars. T_{eff} were taken from Fekel&Balachandran (1993). M_{bol} values were obtained by using the standard procedure in Allen (1973) on the basis of M_v values calculated by using Hipparcos parallaxes. The Schaller et al. (1992) evolutionary tracks for solar chemical composition were used. Most of these giants are evolved after the base of the RGB. Hence, it seems that the activity in the single giants is not just a brief episode. Another explanation is that they become active after the stage of the base of the RGB. The recent studies of the convective envelope evolution during the first acsent on the RGB (Boothroyd&Sackmann, 1999) favour the second assumption. According to these authors the convective envelope is developed completely and could have a deep penetration to the faster rotating stellar interiors on the RGB, not in its base. It is possible that the angular momentum transfer and its distribution within the star happen then and trigger the dynamo action.

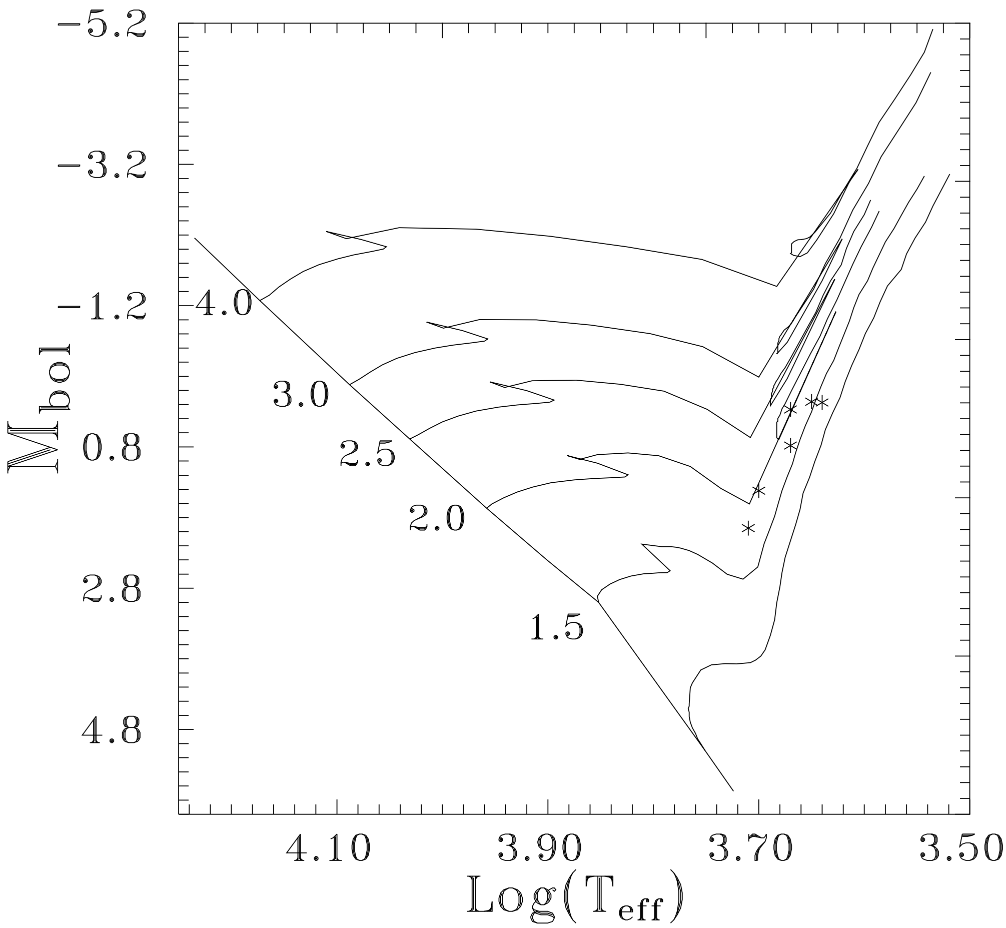

Figure 1: Situation of the active giants on the H–R diagram.

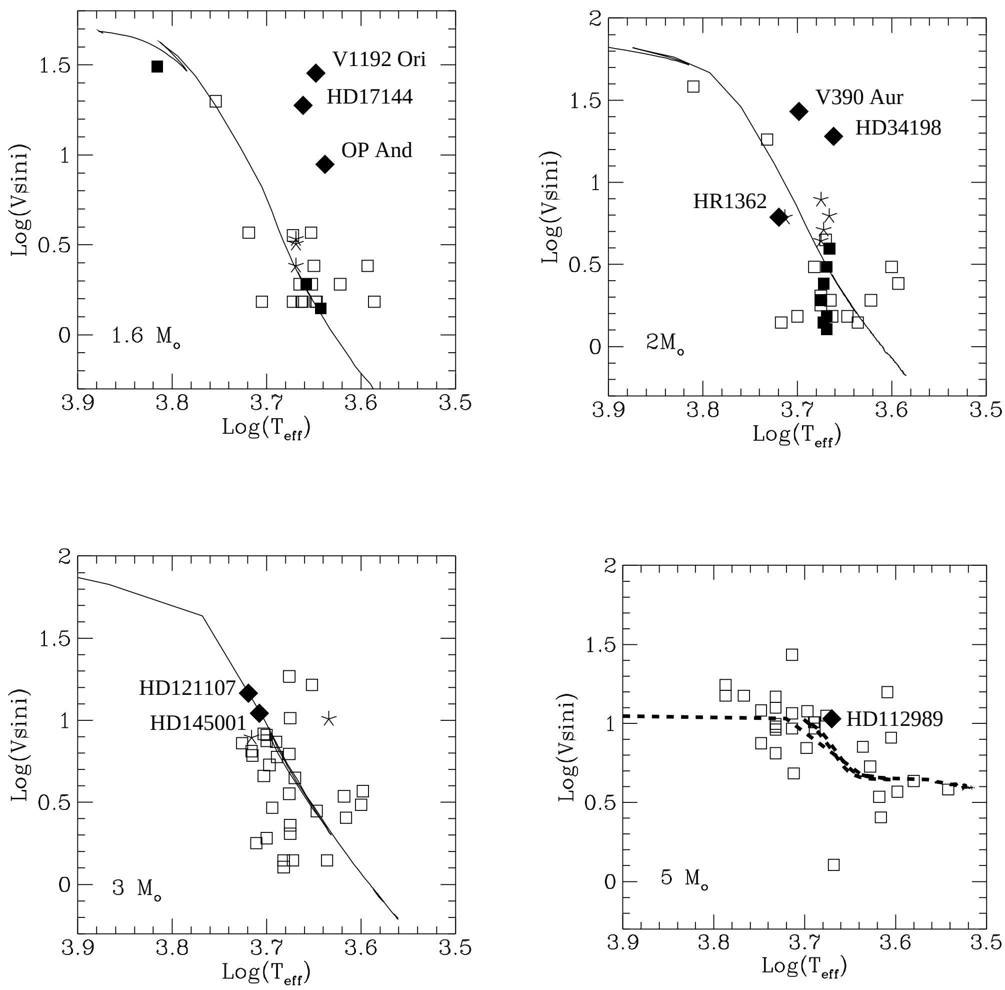

Figure 2: The position of the active giants on the diagram Log(T$_{eff}$)–Log(Vsini). The evolution of the rotation with the age for stars with different masses is adopted from Pasquini et al. (2000). The distribution of their sample stars is also presented in order to make a comparison with the studied active giants.

A study of the angular momentum evolution and rotational behaviour in evolved stars was done by Pasquini et al. (2000). They followed the evolution of the rotation in low and intermediate mass stars based on a representative sample of more than 100 field- and cluster giants. A large scatter in the Vsini values and deviation from the law IΩ=const was observed in the stars in the interval 1.6–3M$_\odot$ (Figs. 9, 10 and 11 in their paper). The comparison with the evolutionary tracks shown in Fig. 1 reveals that this rotational behaviour corresponds to the middle part of the RGB. It seems, there are both slowly and faster rotating stars at this stage of the evolution. A dependence of the CaII emission fluxes upon the rotation was also found. These facts lead to the conclusion that the activity level of these objects depends mainly on the rotation.

The positions of most of the active giants from the Fekel&Balachandran (1993) sample on the relevant diagrams Log(T_{eff})–Log(Vsini), adopted from Pasquini et al. (2000) are shown in Fig. 2. Some fast rotating intermediate mass giants with evidences for chromospheric activity are added too. Their evolutionary stage is presented in Fig. 3. It was determined in the same way as for the giants presented in Fig. 1. T_{eff} and metalicity data published in Brown et al. (1989) were used for them. Vsini values were taken from De Medeiros&Mayor (1999) for all these stars. The most active giants deviate significantly from the rotational distributions for their mass. But the stars which exhibit a moderate activity do not deviate from these distributions in a significant degree. It is worth to point on the fact that the last ones are predominantly stars of intermediate mass at different evolutionary stages.

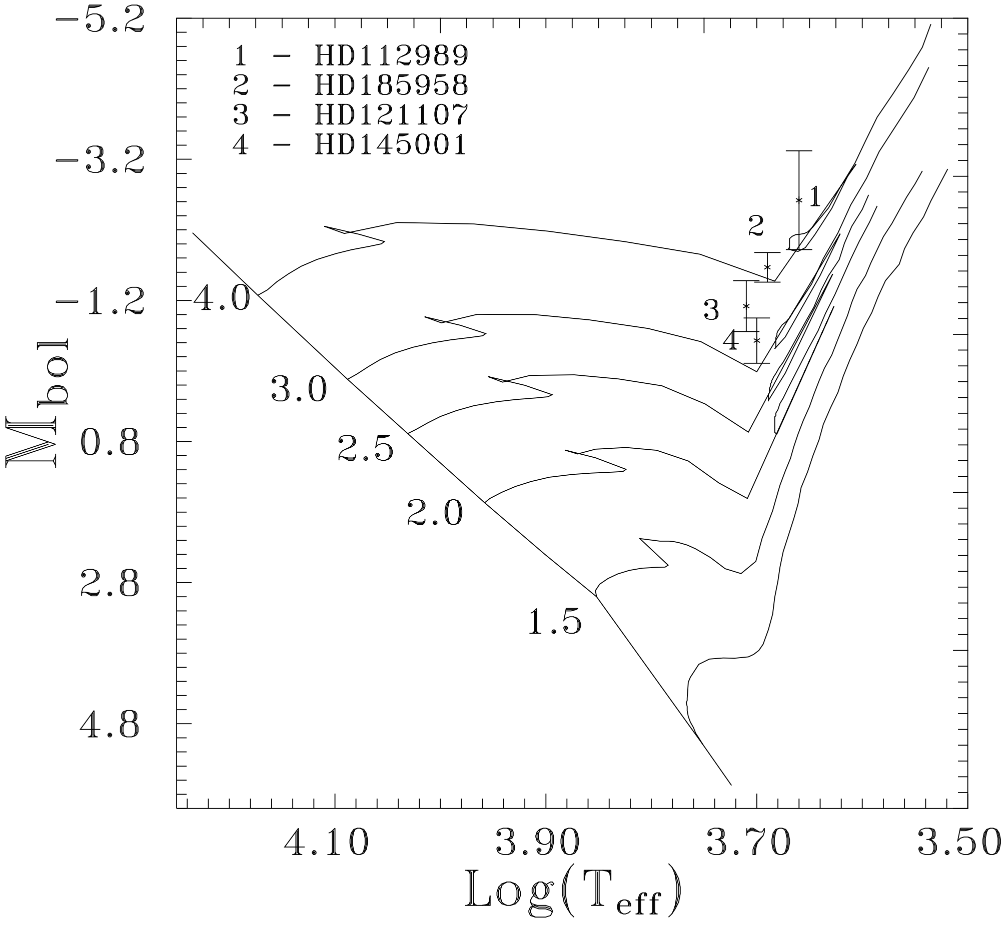

Figure 3: Situation of the intermediate mass faster rotating giants on the H–R diagram.

The stars that deviate from the rotational law for their mass in a significant degree are predominantly (with one exception, the fairly evolved $5M_{\odot}$ giant HD112989) low mass stars. They all are evolved after the base of the RGB.

The masses of these stars are in the range 1.5–2$M_{\odot}$. A conclusion could be drawn that a specific evolution of the convective envelope in these stars leads to the observed higher rotational velocities and activity levels.

The properties of the weaker activity in the intermediate mass giants discussed here is still poorly investigated. The first results (De Medeiros et al., 1999; De Medeiros&Konstantinova–Antova, 2000) pointed on the existing difference in the activity levels in them and low mass ones. A further study could shed light on the reason for different activity behaviour and dynamo action in these stars.

Acknowledgments

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The Hipparcos Catalogue has been used.

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