BEHAVIOUR OF MICROTURBULENCE WITH EVOLUTION

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It is reasonable to suppose that the state of the convective zone underlying the atmosphere of cool stars correlates with the atmospheric kinematics. Following Iben (1967), as a star evolves from the red giant tip to the helium burning core phase, the convection rapidly decreases. Then the microturbulence can be expected to decrease too.

To observationaly check this, I have analysed in detail a sample of 21 G and K giants. I have found that the microturbulent velocities ξ lie

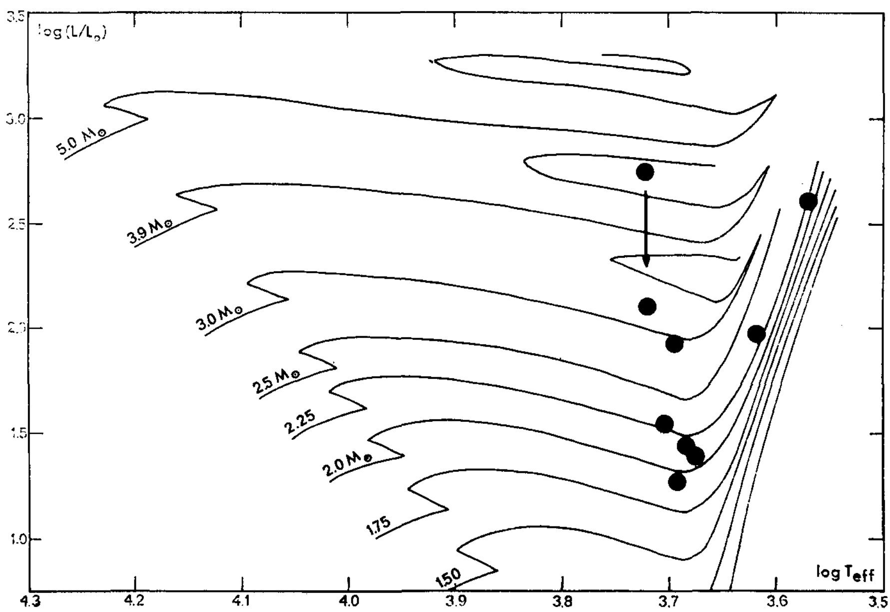

fig 1. Theoretical HR diagram for eight Hyades giants.

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around ξ = 1.5 km/s. But few giants have a markedly lower value of ξ , that is to say $\xi \lesssim 1.0$ km/s. Careful discussions of available data allow one to conclude that these low microturbulence stars are likely in the helium burning core phase.

For example, on the grid of evolutionary tracks shown in figure 1, I have plotted the eight Hyades giants of the sample. A difficulty occurs only for HD 71369. Assuming it is evolving, as the other ones on the red giant branch would imply that its mass is larger than 4 $\mathcal{M}_{\odot}$, which is very much too large for a Hyades star; therefore HD 71369 is not evolving on the red giant branch, and so has to be in the helium burning core phase. Then its mass is near 2 $\mathcal{M}_{\odot}$, which quite agrees with that deduced from the dynamical parallaxe, namely 1.5 $\mathcal{M}_{\odot}$. Its location then moves as shown by the arrow of figure 1. This result is supported by the one magnitude brighter luminosity of HD 71369 with respect to the other Hyades giants with similar R-I coulour indices, as shown by Eggen (1972).

But HD 71369 has another peculiarity: it has a markedly lower microturbulence ξ = 0.8 km/s than the seven other stars, for which a mean value is $\langle\xi\rangle$ = 1.55 ± 0.14: this difference is highly meaningful.

Therefore, in the case of HD 71369, we have equivalence between giant with an helium burning core and low microturbulence giant. Five other stars lead to the same conclusion.

The identification of the helium burning core phase will ever be open to criticism in the case of field stars. Therefore, I have also studied how the microturbulence varies along the red giant branch where stars have a very much greater probability to be observed. This work has been done with my student Luc Vigneron.

We have redetermined physical atmospheric parameters of 74 stars for which line equivalent width data are available in literature. From this work, the effective temperature appears to be not correlated with ξ . But the gravity is strongly correlated with ξ : ξ increases as g decreases(fig2).

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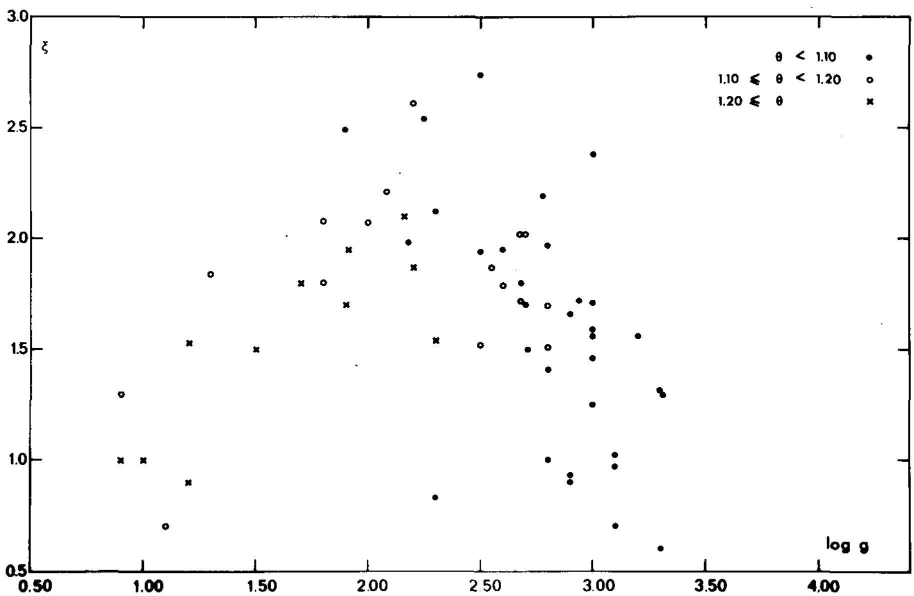

fig 2. Microturbulent velocity ξ versus logarithm of the gravity for cool giants.

As a star evolves along the red giant branch, both its gravity and its effective temperature decrease: note that the temperature also decreases along this sequence. I think that if we project evolutionary tracks on the ξ/log g plane, the red giant branch would be on the rightdecreasing part and the helium burning core branch would be on the left increasing part, since, with the exception of HD 71369 (log g = 2.2; ξ = 0.8), the giants which are very likely in the helium burning core phase lie on this second branch.

This correlation between microturbulence and degree of evolution is also shown in the theoretical HR diagram of figure 3. This diagram shows a segregation in the sense that the most evolved stars have a larger microturbulence than the less evolved ones.

I wish to emphasize the three main conclusions from the present study.

Firstly, the microturbulence in cool stars is a real phenomenon and not a spurious effect, as claimed, for instance by Worrall and Wilson (1972).

Secondly, the microturbulence is a good indication of the degree of evolution of giants. It allows us to distinguish between field stars on the

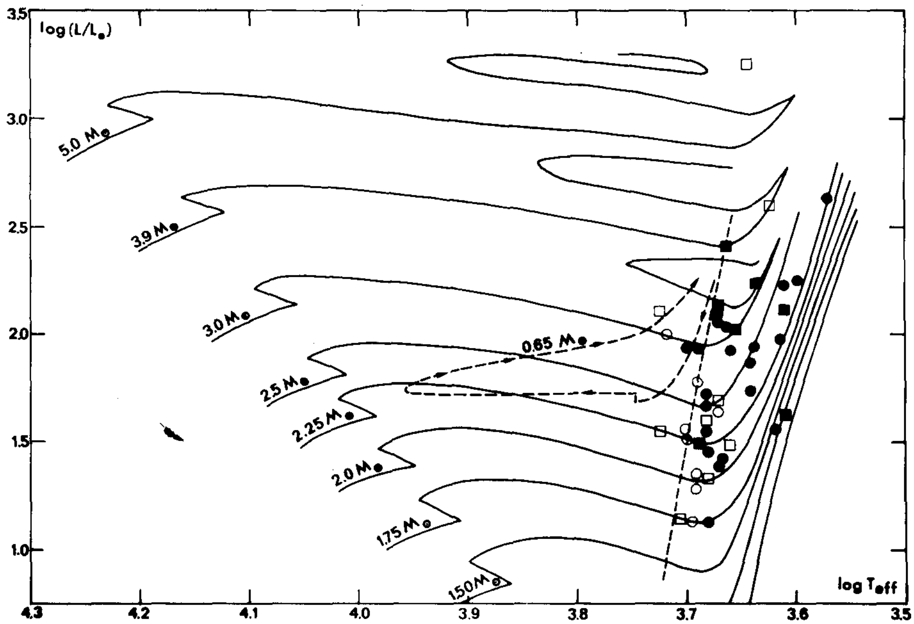

fig 3. Theoretical HR diagram for reanalysed cool giants. Open and filled symbols respectively refer to low and high values of the microturbulent velocity.

horizontal branch and the red giant branch.

Thirdly, the microturbulence in stellar photosphere of cool stars varies as the strength of the underlying convective zone: this supports the idea that microturbulence is induced from convection, presumably by the mechanism of overshooting.

References

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