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New Acoustic Wave Energy Computations for Late-Type Stars

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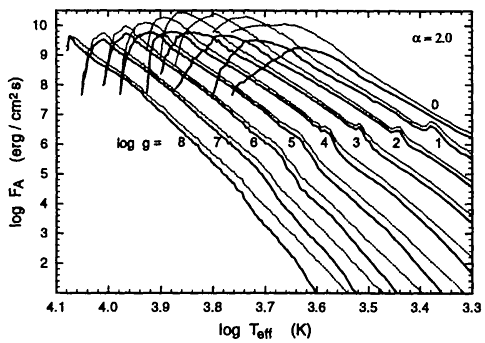
Abstract. We compute the acoustic wave energy generation by turbulent convection in late-type stellar atmospheres on basis of improved turbulent energy spectra close to the Kolmogorov spectrum. Such spectra are suggested from observations and from numerical convection simulations. Different from Bohn (1984) we find that our new acoustic fluxes are close to those given by the Lighthill-Proudman formula. Our new computations indicate very low acoustic fluxes for M-stars which, however, are still consistent with observed Mg II core emission fluxes.

1. Method and Results

Following Musielak, Rosner, Stein & Ulmschneider (1994) we have recomputed the acoustic wave energy, generated in the convection zones of a large number of late-type stars using Stein's theory, on basis of grey LTE mixing-length models with a mixing-length parameter of $\alpha = 2$ and improved opacities. Figure 1 shows the resulting acoustic fluxes. These fluxes are described in more detail in our paper Ulmschneider, Theurer & Musielak (1995). In our calculations the turbulence is represented by an extended Kolmogorov energy spectrum with a modified Gaussian frequency factor (eKmG-spectrum) which presently is thought to represent best the observations and numerical convection simulations. The value of α was chosen for best agreement with the maximum convective velocities in solar simulations. Figure 1 also shows the close agreement of our new fluxes with the acoustic fluxes computed on basis of the Lighthill (1952) – Proudman (1952) formula.

2. Comparison with Observations

Our new fluxes, particularly for M-dwarf stars, are very different from those obtained by Bohn (1984). This is due to his use of the unrealistic EE-turbulence spectrum and to computational errors. Using values of $T_{\rm eff}$, $B-V$, M and $\log g$ from Schmidt-Kaler (1982, pp. 15, 31, 453) we have computed total acoustic



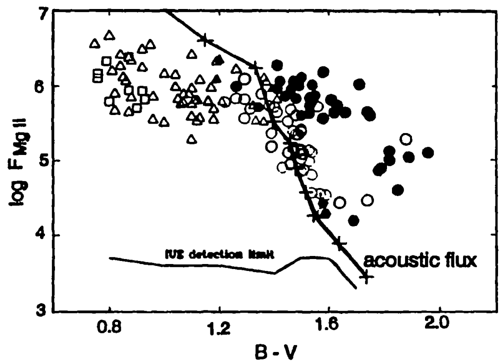


Figure 1. (left) Total acoustic fluxes (drawn) versus $T_{\rm eff}$ for population I stars of different log g, using the eKmG-spectrum and $\alpha = 2$. Fluxes computed with the Lighthill-Proudman formula are shown dotted.

Figure 2. (right) Individually computed total acoustic fluxes for K and M main sequence stars versus $B - V$ as compared with observed stellar Mg II core emission fluxes by Mathioudakis & Doyle (1992).

fluxes for all tabulated main sequence stars of spectral type K0 to M8. The results are plotted in Figure 2, together with observed Mg II line core emission fluxes by Mathioudakis & Doyle (1992). For $T_{\rm eff} > 3500$ K or $B - V < 1.5$ these acoustic fluxes are by more than a factor of 10 larger than the lowest Mg II fluxes, while below this temperature they are at least comparable. In such a comparison it should be noted that mechanical heating, in addition to Mg II losses, must also balance emissions in the Ca II and Fe II lines as well as the H^- continuum. Thus Figure 2 may indicate that the latest observed M-dwarfs are still mainly heated by magnetic mechanisms or, even more likely, that our grey treatment of molecules and our used opacities are inadequate. As discussed by Ulmschneider et al. (1995), added molecular opacities will lead to larger acoustic fluxes. Thus our new flux computations appear not to be inconsistent with the assumption that the basal flux M-stars are heated by acoustic waves.

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