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THE REFLECTION EFFECT IN MODEL STELLAR ATMOSPHERES I: GREY ATMOSPHERES WITH CONVECTION

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SUMMARY: The effects of the mutual illumination of the components of binary systems are investigated, by introducing an external radiation field in a model for plane-parallel stellar atmospheres in radiative + convective equilibrium. For grey atmospheres in radiative equilibrium, the results are verified against exact solutions.

In general, the external illumination causes a heating of the atmosphere. For models in radiative equilibrium, the heating is such that all incident energy is re-emitted by the atmosphere (bolometric reflection albedo equal to one). The frequency distribution of the re-emitted energy is described in terms of a frequency dependent effective reflection albedo, for which approximate numerical expressions are given.

For models in radiative + convective equilibrium, not all the incident energy is re-emitted. By requiring the entropy in the deep convection zone to be the same in the illuminated and non-illuminated parts of a reflecting star, bolometric reflection albedos for the illuminated parts may be determined. For the particular case of Algol, good agreement with observational results are obtained. In some cases (especially for small angles of incidence), the bolometric reflection albedo may become negative. This is shown to be the net result of two competing effects, where the strong temperature sensitivity of the continuum opacity plays a major role. For a particular reflecting star (main sequence, T_{eff} = 4500 K), results are given for the bolometric reflection albedo as a function of angle of incidence and relative incident energy flux.

Changes in the limb-darkening due to illumination are also discussed and it is shown that, at least for grey atmospheres, a convenient numerical expression may be given for the reduction of the limb-darkening as a function of frequency, angle of incidence, and relative incident flux.

Key words: stellar atmospheres, convection, binary stars, reflection albedo.

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