Bhatnagar, P. L., M. Krook and R. N. Thomas. Kinetic temperature, electron temperature and turbulence in stellar atmospheres.

Three assumptions characterize the normal stellar atmosphere model: hydrostatic equilibrium, radiative equilibrium, local thermodynamic equilibrium. Ignoring spectral excitation features, the chromosphere-corona atmosphere is characterized by two gross features inconsistent with the normal model:

(a) The large extent of the chromosphere-corona: the low density gradient.

(b) High values of T_ϵ and T_k somewhere in the chromosphere-corona.

The existence of (a) is inferred from an observed emission gradient, but the precise density gradient can be determined only when (b) is resolved.

It seems generally agreed that, to resolve (a) and (b), the normal model must be modified by introducing some kind of field of mechanical motion. Two extreme models for such modification have been proposed to explain (a):

(a.1) Models involving some type of purely macroscopic motions, loosely termed turbulence. No quantitative theory has been presented for the generation of such macroscopic motions, nor for the coupling with thermal motion. Even though the turbulence velocities are superthermic, it is implicitly assumed that any coupling with thermal motion shall not appreciably affect the atmospheric kinetic temperature. Solar eclipse observations restrict the tangential component of any macroscopic velocities to less than about 2 km/sec, but the above models have generally assumed the turbulence isotropic.

(a.2) Models involving a high T_k in the atmosphere. The basic hypothesis states that any field of superthermic macroscopic motions sufficient to alter non-trivially the atmospheric density gradient implies a non-trivial rise in atmospheric T_k. The range of such models depends upon the relative significance of the energy and of the momentum supplied by the macroscopic field. Radio observers state T_ϵ must be lower than the T_k needed for such a model in the sun. All models assume $T_\epsilon = T_k$.

The self-consistency of either models (a.1) or (a.2) thus seems questionable. Three alternatives appear to span the range of resolution of the difficulty:

(1) Turbulence must be replaced by radial turbulence—a system of jets, or prominences, whose main function is to match (a) without heating the atmosphere significantly at the lower heights.

(2) The interpretation of the radio observations which provide the low values of T_ϵ must be shown invalid; e.g., by departures from the Maxwellian velocity distribution.

(3) A high T_k must be reconciled with a low T_ϵ.

Various reports in the literature,[1] especially concerning discharge-tube phenomena, state the possibility of configurations with T_ϵ significantly different from T_k. We have investigated the problem, theoretically, and conclude T_ϵ cannot differ significantly from T_k for $T_\epsilon \gtrsim 10^8$ °K. We discard (3) above, then, and question the validity of such reports as that cited.

1. E.g., H. Alfven, *Cosmical Electrodynamics*, pp. 44–46, 1950. The treatment in this reference violates the conservation of energy.

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