# STELLAR CORONA MODELS

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A new method of calculating models for stellar coronae is being developed with the aim of providing models of coronae around hot stars capable of explaining the observed mass loss as a stellar wind from a hot corona. The method gives a stationary solution to the coupled equations of motion, continuity and energy balance. The equation of motion contains only the gradient of the gas pressure and the acceleration due to gravity. Radiation pressure is not yet included. The continuity equation assumes spherical symmetry. The energy equation includes heating by weak shock waves, heating by the absorption of photospheric radiation through continuous opacity, radiation losses, heating or cooling by conductivity and the effect on the energy balance of the velocity of the expanding atmosphere. The model is assumed to be optically thin. The velocity distribution is calculated from the solution going through the critical point.

Previously these equations have always been solved as initial value problems. But to do this one must specify at the beginning of the calculation the mechanical flux, the pressure, the temperature and its gradient and the velocity and its gradient, and these are specified at the bottom of the transition region. Such a method of solution contradicts an important conclusion of the minimum flux corona theory (Hearn 1975) that only the mechanical flux heating the corona is a free parameter, and that the pressure of the transition region, the average temperature of the corona and its mass loss are parameters specified by the heating of the corona.

In the new method the temperature structure of the corona is calculated iteratively in a two boundary value solution. The boundary condition at infinity is that the temperature tends to zero. The beginning of the solution is set at a density that is so high that the dissipation of the weak shock waves is negligible and that the temperature of the atmosphere is determined by a simple radiative equilibrium. If these conditions are met the only free parameter for the solution of the equations for a given star is the initial flux of mechanical energy. Further the position and temperature structure of

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the transition region is determined entirely by the calculation itself.

This method is still under development but some provisional results have been obtained for coronae with small mass loss. Firstly the solution is unique, even though the mechanical flux is the only free parameter of the solution. If the final solution is perturbed, the solution converges back again to 4 significant figures. Secondly, models have been obtained which have a second transition to an outer region which is in radiative equilibrium. In one calculation with a mass loss of only $10^{-12}\ M_\odot\ yr^{-1}$ the corona was reduced to 4 stellar radii in thickness. The outer region in radiative equilibrium results from the large radiative losses which prevent thermal conduction from maintaining coronal temperatures in the outer layers.

## REFERENCE

Hearn, A.G.: 1975, Astron. Astrophys. 40, pp. 355-364.

## DISCUSSION FOLLOWING HEARN AND VARDAVAS

Snow: In the solution where you found a corona extending out to 4 R*, what was the temperature of the corona?

Hearn: Two million degrees.

Cassinelli: Are the thermal velocity and flow velocity at the top of your coronal zone related in a simple way to the escape speed of the star?

Hearn: This is determined by the critical point of the Parker solution. In our present model calculations the critical point lies at about 3.5 R*.