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# Propagation of magnetohydrodynamic shock waves in stellar interiors

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The propagation of magnetohydrodynamic shock waves in a polytropic star has been examined in the presence of physically realistic magnetic fields. Radiation effects have been ignored.

The structure of a polytrope in equilibrium with a toroidal magnetic field has been investigated first, in the framework of a first-order perturbation theory, with a view to studying the propagation of shock waves in this medium. This investigation reveals that the structure of the polytrope is modified considerably by the presence of the magnetic field. It is found that the inhomogeneity in the density distribution is reduced, and there is a change in the mass of the polytrope. Furthermore, the polytrope is distorted and is no longer spherical.

The problem of shock propagation has been studied in the presence of a toroidal field and in the presence of a poloidal field. Butler's method is extended to deal with the problem in the case of a toroidal field, whereas an extension of Whitham's method is applied to tackle the problem in the case of a poloidal field. The transition in the physical state of the medium undergone by the passage of a magnetohydrodynamic shock is specified in terms of two parameters: one giving a measure of the shock strength, and the other expressing the importance of the magnetic field. Both in the cases of a toroidal, and of a poloidal magnetic field it is found that the passage of stronger shocks always brings about a greater increase in the density ratio and the pressure ratio across the shock front. As expected, the density ratio is found never to exceed a finite limit. The particle velocity behind the shock front also increases more for stronger shocks. The presence of a magnetic field gives rise to some interesting changes in the effects produced by the passage of a shock.

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A magnetic field tends to restrain the growth of pressure, and this effect becomes quite significant in the presence of a toroidal field. As a result, the rise in temperature due to the passage of a shock in a polytrope is inhibited. Thus the intense heating of the medium during the passage of a shock is reduced and consequently the growth of higher nuclear reactions is truncated. A magnetic field gives rise to a nonuniformity in the shock velocity along the front, and therefore, the front is distorted and becomes an ellipsoid of revolution to a first approximation. The particle velocity behind the shock front continuously rises. A poloidal field has the effect of increasing this growth, whereas a toroidal field tends to impede it. Nevertheless, the escape velocity will, in general, be attained inside the star in both cases if the shock is of moderate strength and thus, in this case, an ejection of mass from the star is possible. However, a magnetic field makes the process of ejection itself interesting by imparting nonuniform velocities to matter behind the front. As a result, ejection patterns of different types may be produced. If, however, the escape velocity is not attained anywhere inside the polytrope, the nonuniform rise in temperature behind the shock front may lead to the generation of circulations in the regions close to the surface.