



Collisionless Shocks in the Heliosphere: A Tutorial Review (Geophysical Monograph Series)

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Violent expansions of the solar corona cause transient shock waves which propagate outward from the sun at hundreds to thousands of kilometers per second; simple solar wind velocity gradients at the surface of the sun lead to high-speed streams overtaking slower streams, forming corotating shocks; and steady state supermagnetosonic solar wind flow past objects such as the planets lead to standing bow shocks. However, the solar wind plasma is so hot and tenuous that charged particle Coulomb collisions produce negligible thermalization or dissipation on scale sizes less than 0.1 AU. The irreversible plasma heating by these shocks is accomplished by wave-particle interactions driven by plasma instabilities. Hence these shocks are described as "collisionless."

Collisionless shocks are interesting and important for numerous reasons. Collisionless shocks are the simplest configuration in which a macroscopic flow is regulated by microscopic dissipation, a problem common to many different plasma processes. Collisionless shocks are therefore of basic plasma physical interest. There are also many important ways in which shocks affect the near-earth environment. Coronal shocks are believed to be responsible for the acceleration of solar flare energetic particles, which then propagate outward to fill the heliosphere. Shock propagation into the outer heliosphere may be a principal cause of the solar cycle dependent cosmic ray modulation. Interplanetary shock interactions with the earth's magnetosphere cause magnetic storms, intense low-latitude aurorae, and radio blackouts. Recent observations of fields and particles near interplanetary shocks and upstream of the earth's bow shock allow us to study particle acceleration processes in situ, giving us first-hand knowledge of processes which are occurring not only in our heliosphere but which may give us important insights into plasma processes which are occurring near distant interstellar shocks, processes which are believed to create cosmic rays.

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