Coronal Mass Ejections, Shocks, and Type II Radio Bursts

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Coronal mass ejections (CMEs) are the most energetic phenomena in the interplanetary medium. Type II radio bursts are the earliest indicators of particle acceleration by CME-driven shocks. There is one-to-one correspondence between large solar energetic particle (SEP) events and long wavelength type II bursts because the same CME-driven shock is supposed to accelerate electrons and ions. However, there are some significant deviations: some CMEs lacking type II bursts (radio-quiet or RQ CMEs) are associated with small SEP events while some radio-loud (RL) CMEs are not associated with SEP events, suggesting subtle differences in the acceleration of electrons and protons. Not all CME-driven shocks are radio loud: more than one third of the interplanetary shocks during solar cycle 23 were radio quiet. Some RQ shocks were associated with energetic storm particle (ESP) events, which are detected when the shocks arrive at the observing spacecraft. This paper attempts to explain these contradictory results in terms of the properties of CMEs, shocks, and the ambient medium.