INTERPLANETARY SHOCKS WITH AND WITHOUT RADIO EMISSION

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The Solar and Heliospheric Observatory (SOHO) has observed interplanetary shocks and the driving coronal mass ejections (CMEs) over a whole cycle (1996-2007). These CME-driven shocks accelerate energetic particles with very high efficiency (about 10% of the CME kinetic energy has been estimated to go into particle energy). Shocks also deliver pressure pulses to planetary magnetospheres signaling the impending magnetic storms. During solar cycle 23, more than 200 shocks were detected in the in situ data. Many of these shocks were also remote-sensed by the Wind spacecraft by observing the type II radio bursts produced by the shocks. The radio emission is caused by keV electrons accelerated at the shock front. Nearly half of the shocks were not accompanied by type II bursts (radio quiet - no radio emission was observed by the Wind spacecraft). These shocks were observed only by in situ observations (SOHO, Wind or ACE). When the CMEs driving the shocks were identified in the coronagraphic images acquired by SOHO, it was found that shocks with and without type II radio emission had distinct properties: CMEs of radio-loud shocks were more than twice faster than those of radio-quiet shocks. CMEs associated with the radio-quiet shocks were accelerating near the Sun on the average, while the ones with radio-loud shocks were decelerating. The explanation for the radio-quiet shocks is that the CMEs accelerate and attain super-Alfvenic speeds only at large distances from the Sun, not being strong enough to accelerate high levels of electrons or ions. In fact, Alfvenic Mach numbers of the radio-quiet shocks at 1 AU were generally low (average $\sim$2.3) compared to those of radio-loud shocks ($\sim$3.7). Finally, the abundance of radio-quiet shocks is higher during the rise phase of the solar cycle, while the radio-loud shocks dominated during the maximum and declining phases of the solar cycle. This relative abundance is consistent with the solar-cycle variation of the average speed of the CMEs, which peaks during the solar maximum and decreases slowly in the declining phase. A combination of the available free energy in solar source regions and the variation in the characteristic speed in the ambient medium might be responsible for such a solar cycle variation.