Low-frequency Solar Radio Bursts and their Space Weather Implications

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The Sun is a radio emitter in the millimeter to kilometer wavelength range (100s of GHz to a few kHz). The low frequency solar radio bursts are of particular importance, because they are associated with large-scale solar eruptions and the associated interplanetary disturbances such as coronal mass ejections (CMEs) and shocks. The radio bursts are produced by energetic electrons (>1 keV) by nonthermal processes. The radio bursts provide important information not only on the solar disturbances but also on the ambient medium.

Three types of nonthermal radio bursts are generally associated with CMEs. Type III bursts due to accelerated electrons propagating along open magnetic field lines. The electrons are thought to be accelerated at the reconnection region beneath the erupting CME, although there is another view that the electrons may be accelerated at the CME-driven shock. Type II bursts are definitely due to electrons accelerated at the shock front. Type II bursts are also excellent indicators of solar energetic particle (SEP) events because the same shock is supposed accelerate electrons and ions. There is a hierarchical relationship between the wavelength range of type II bursts and the CME kinetic energy. Finally, Type IV bursts are due to electrons trapped in moving or stationary structures. The low-frequency stationary type IV bursts are observed occasionally in association with very fast CMEs. These bursts originate from flare loops behind the erupting CME and hence indicate tall loops.

This paper presents a summary of recent results obtained using the Radio and Plasma Wave (WAVES) experiment on board the Wind spacecraft along with white-light coronagraph observations from the Solar Heliospheric Observatory (SOHO) mission. In particular, the role of low frequency type II bursts in understanding CME propagation and SEP association will be discussed. Other propagation effects such interaction with preceding CMEs and the resulting modification of the type II burst properties will be discussed. When the shocks arrive at 1 AU, they are significantly weakened; some shocks die off before arriving at 1 AU. The association with a type II burst does make a difference in the magnetospheric response of CME-driven shocks: the strength of sudden impulse/sudden commencement. Finally, shocks associated with a type II burst somewhere in the inner heliosphere are more likely to produce energetic storm particle events compared to those that are radio quiet (no type II association).

Finally, the implications of the weak state of the heliosphere on the occurrence of type II bursts will be discussed. Solar cycle 24 is extremely weak resulting in a diminished density, temperature, and magnetic field in the heliosphere. The resulting weak total pressure (magnetic + plasma) affects CME propagation, including the shock formation, wavelength range of type II bursts, and the association with SEP events.