H_2 in the Molecular Supernova Remnants W 28, W 44, and 3C 391

William T. Reach and Jeonghee Rho
IPAC/Caltech MS 100-22, Pasadena, CA 91125

We present *Infrared Space Observatory* spectroscopy of sites in the supernova remnants W 28, W 44, and 3C 391, where the blast waves are impacting molecular clouds. The complete wavelength ranges of 42–188 μm and (at low resolution) 5–16 μm were observed, as well as narrow ranges centered on 25.98 and 34.82 μm. Atomic fine-structure lines were detected from (in order of atomic number): C^+, N^+, N^{++}, O^0, O^{++}, O^{+++}, Ne^+, Si^+, P^+, Cl^+, Ar^+, and Fe^+. The observations demnstrate that the principal coolants of radiative supernova shocks in moderate-density gas are the [O I] 63.2 μm line and the [Si II] 34.8 μm, with the Si and Fe coming from crushed interstellar grains. The presence or lack of all atomic fine lines in our spectrum is explained in terms of the atomic structure, interstellar abundances, and a moderate-density, partially-ionized plasma. For the plausible ionization states of elements with abundance greater than 10^{-7} relative to H, our LWS spectra cover the wavelengths of 10 lines among energy levels within 500 K of ground; all of these lines were detected. Our SWS spectra contain 3 such lines, which were detected. The abundances of Si and Fe relative to O are consistent with solar abundances, proving that the dust grains are nearly completely destroyed by the shock. The [P II] line at 60.6 μm is the first known astronomical detection; the abundance of P is also consistent with solar abundances. There is one unidentified line in our spectra, at 74.26 μm; as there is no plausible atomic fine-structure line at this wavelength, we suspect this line is molecular.