Millimeter Emission from Supernovae in the Very Early Phase: Implications on the Dynamical Mass Loss of Massive Stars

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Recent high-cadence transient surveys and rapid follow-up observations have revealed that some massive stars dynamically lose their own mass within decades before supernovae (SNe). Such a mass-loss forms confined circumstellar medium (CSM); a high density material distribution only in small radius ($\lesssim 10^{15}$ cm with the mass-loss rate of $0.01 \sim 10^{-4}$ $M_{\odot}\mathrm{yr}^{-1}$). While the SN shock triggers particle acceleration and magnetic field amplification in the confined CSM, synchrotron emission may be masked in centimeter wavelengths due to the free-free absorption; the millimeter range can however be a potential new window. We investigate the time evolution of synchrotron radiation from the system of red super giant surrounded by the confined CSM, relevant to typical type II-P SNe. We have revealed that synchrotron millimeter emission is generally detectable, and the signal can be used as a sensitive tracer of the nature of the confined CSM; it traces different CSM density parameter space than in the optical. Furthermore, our simulations show that the confined CSM efficiently produces secondary electrons and positrons through proton inelastic collisions, which can become main contributors to the synchrotron emission in several ten days since the SN. We predict that the signal is detectable by ALMA, and suggest that it will provide a robust evidence of the existence of the confined CSM.