The Evolution of Dust in the Ejecta of Core Collapse Supernovae

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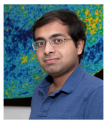

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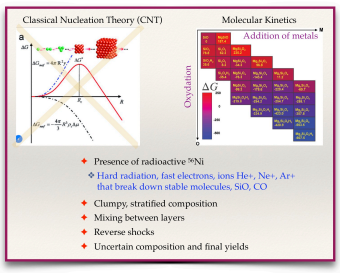
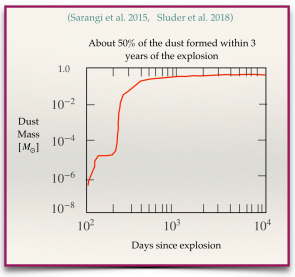
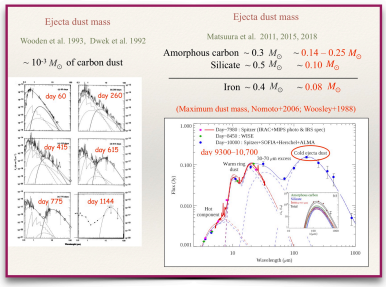
(1) There are basically two approaches for modeling the formation of dust in the ejecta of CCSNe: CNT and Molecular Kinetics.



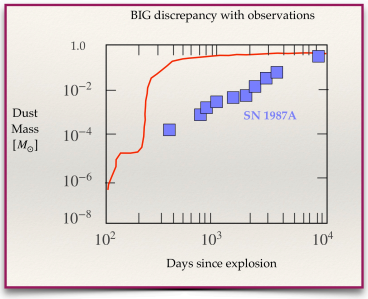
(2) Both predict the RAPID formation of dust in the ejecta. Most of the dust , about 0.5 Msun, forms within 3 years of the explosion.



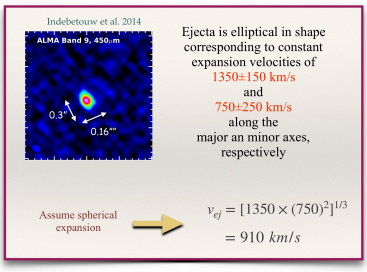
(3) Only 10^{-3} Msun of dust had been inferred from observations of SN1987A on day ~1000. Later, on day ~10,000, the mass of dust inferred from observations increased to about 0.5 Msun. This trend has been suggested as evidence for the SLOW formation on dust in the ejecta.



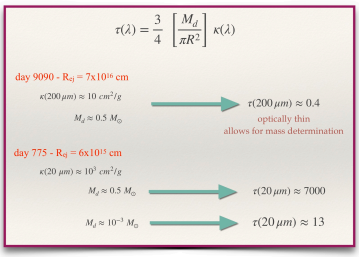
(4) The discrepancy between theory and observations.



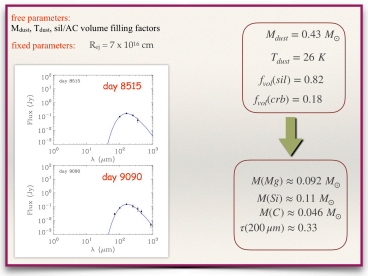
(5) Observations of the ejecta and its kinematics show that if the expansion is played BACKWARDS the ejecta would be optically thick at infrared (IR) wavelengths.



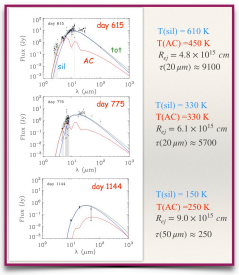
(6) About 0.5 Msun of dust could have been "hidden" in the ejecta at early times.



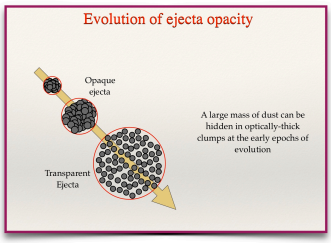
(7) After day ~ 8,000 the ejecta is thin revealing its total dust content: about 0.4 Msun of dust.



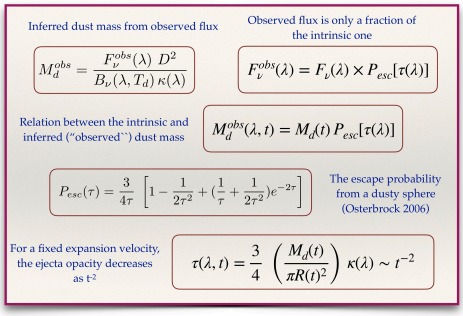
(8) The spectra at early epochs can also be fit with ~0.4 Msun of dust, if the opacity of the ejecta is taken into account.



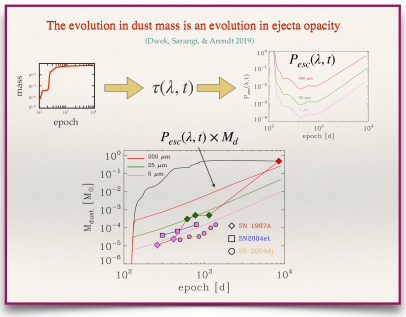
(9) The evolution in dust mass is actually an evolution of ejecta opacity. Dust formed rapidly, but reveals itself slowly as the ejecta expands.



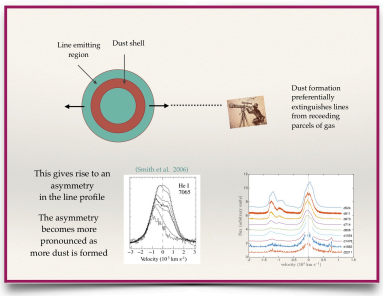
(10) A simple model predicts that the mass of the observable dust should increase as R^2 or t^2.



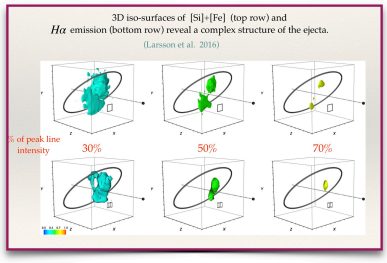
(11) Comparison with several young supernovae confirms the trend.



(12) It has been argued that the gradual evolution in line asymmetry is evidence for the slow formation of dust in the ejecta.



(13) However, these arguments and models do not take the complex morphology of the ejecta into account



Summary

"Dust ball" from Miyazaki's animated movie "Spirited Away"

- Determining the dust mass in SN ejecta must take the ejecta opacity into account
- The apparent slow evolution in dust mass is actually an evolution in ejecta opacity
- Most of the dust in CCSNe forms rapidly, within 3 years after the explosion
- The presence of dust affects the cascade of high-energy photons and UV-opt line emission from the ejecta
- Evolution of IR emission can be used to infer ejecta dynamics
- Modeling the evolution of line asymmetries is difficult because of the complex structure of the ejecta, and the location of the newly-forming dust

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