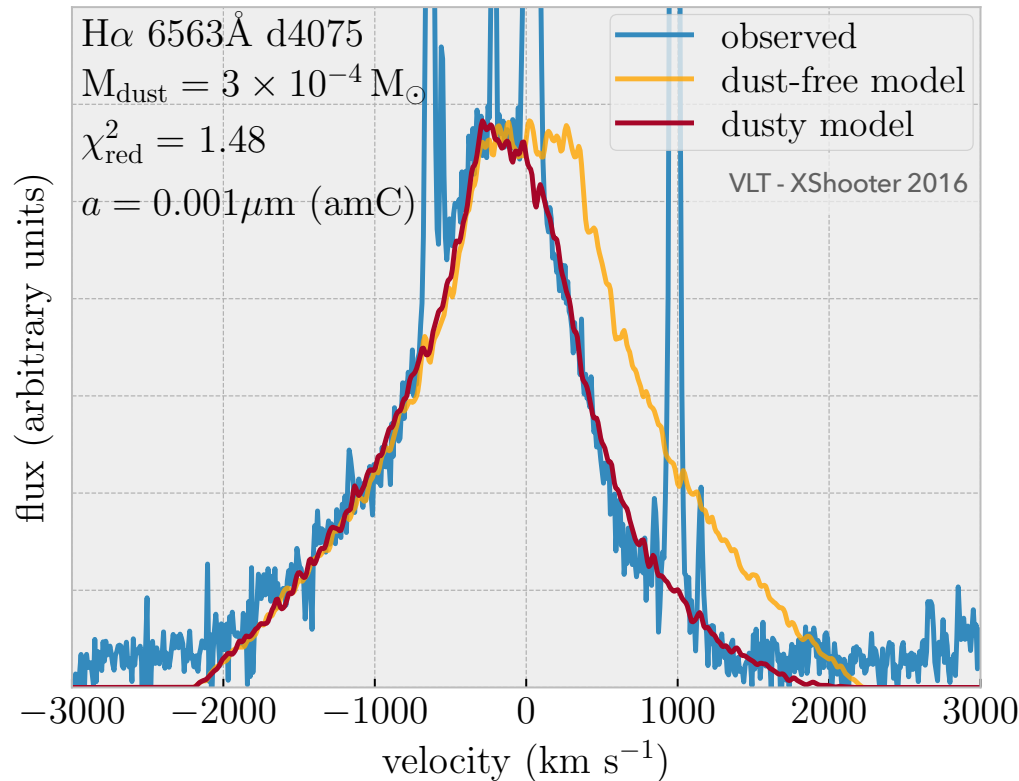


DUST FORMATION IN SN 2005IP

Antonia Bevan - POSTER 124



- Dust masses in Type II n SN 2005ip from optical line profile evolution
- Second SN to have dust mass evolution traced
- Dust growth or dust destruction?

DUST FORMATION IN SN 2005IP

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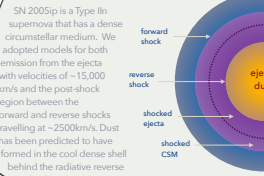
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Introduction

The source of the large masses of dust observed in some very early Universe galaxies at redshifts $z \approx 6$ has been much debated. The discovery of large masses of cold dust in a few nearby core-collapse supernovae (CCSNe) suggests that CCSNe could be efficient producers of dust but there are currently no telescopes that are capable of detecting cold dust in the far-IR in extragalactic CCSNe and remnants. However, dust formation in the ejecta of CCSNe can induce persistent asymmetries in their optical and NIR line profiles due to greater

attenuation of redshifted radiation which must traverse the dusty interior. By modelling these lines the dust mass in the ejecta can be inferred (Bevan+ 2016). SN 2005ip is a well-observed II n SN that has remained bright for years after outburst due to its ongoing interaction with circumstellar material. We present MCRF models of dust-affected line profiles tracing the evolution of dust formation in SN 2005ip.

MODEL STRUCTURES



LINE PROFILE MODELS OF SN 2005IP

Spitzer (3.5 - 15 μm) observations of SN 2005ip at 935d post-discovery revealed two distinct dust components associated with the object: a warm component believed to be pre-existing dust in the CSM ($M_{\text{dust}} \approx 0.05M_{\odot}$) and a hot component ($M_{\text{dust}} \approx 5 \times 10^{-4} M_{\odot}$) that is thought to be dust within the SN (Foxe+ 10). These single epoch observations do not trace newly formed cold dust in the ejecta or post-shock region and so potentially underestimate the total dust mass in SN 2005ip. They also do not predict how the dust mass may have evolved over the last decade. However, further evidence of dust formation in SN 2005ip comes from the progressively blueshifted H α and H α 7065 Å line profiles.

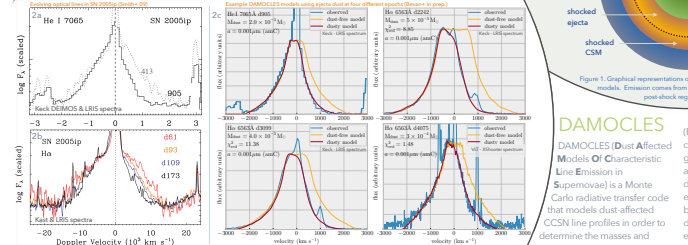


Figure 2: a) The intermediate width He I 7065 Å line profile evolved from the post-shock region at 413d and 935d showing increasing attenuation of the red side of the profile as a result of dust formation in the SN interior. b) The broad H α line profile exhibiting increasing extension of the red side of the profile at early times due to dust formation in the ejecta. c) Example DAMOCLES fits to the intermediate width He and H α lines from 935d to 4075d with adopted parameters indicated.

We modelled the broad H α profile at early times with gas emission coming from the ejecta and dust co-located with the gas. We also modelled the intermediate width H α and H α 7065 Å lines emitted from the post-shock region at later times for two cases: one with dust entirely within the ejecta, and one with dust entirely within the post-shock region. In all cases, the dust mass was relatively insensitive to all parameters except the grain radius. We therefore investigated the most absorbing grain size in order to identify a lower limit to the dust mass, as well as large grains ($a \approx$

Conclusions

We have modelled in detail the dust mass evolution in SN 2005ip from early (43d) to late times (4075d) by fitting the broad and intermediate width H α line and the intermediate width H α 7065 Å line using the Monte Carlo radiative transfer code DAMOCLES (Bevan+ 16). We adopted models with emission emanating from the fast-moving ejecta at early times (<2000d) and from the post-shock region at later times (>2000d). The increasingly blueshifted H α line at early times indicates dust formation in the ejecta. We find that very little dust is required to reproduce the observed asymmetry at this time ($\sim 10^{-4} M_{\odot}$). At later times, we require a relatively steady $\sim 4 \times 10^{-4} M_{\odot}$ to fit the profiles with post-shock dust. However, better fits can be obtained by requiring the dust to reside in the ejecta. In this case, we can place lower limits on the dust mass and

identify a steady growth in the dust mass to 30000d. After this, we find that the lower limit decreases. This could suggest that the reverse shock is passing back through the ejecta and destroying or breaking up the dust grains. Alternatively, it could suggest that the grains are growing over time as has been observed in several CCSNe including SN 1987A (Wesson+ 15, Bevan+ 16, 17). Further work to constrain the grain radius is required to resolve this dichotomy. For SN 2005ip, the dust mass estimates and growth rate are in good agreement with SN 1987A.

THE DUST MASS IN SN 2005IP OVER TIME

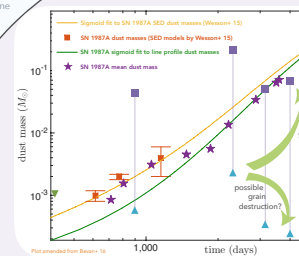


Figure 3: The evolution of dust in SN 1987A from DAMOCLES line profile modelling (light and dark blue, and the green triangles) and the dust mass in SN 2005ip from the SED model by Wesson+ 15 (red squares and the yellow signoid curve). Turquoise triangles indicate the strict lower limit to the SN 2005ip upper limit while purple triangles indicate the minimum dust mass for Sun grains. The inferred post-shock region dust mass evolves very little at late epochs, plateauing dust masses inferred from the DAMOCLES models are plotted in Figure 3. Prior to this (for small grains of $\sim 0.08\mu\text{m}$) are in good agreement with the ejecta dust mass limits (for larger grains of $\sim 0.5\mu\text{m}$) are in good agreement with the ejecta dust mass limits. From 30000d onwards, the lower of the $a = 5\mu\text{m}$ dust mass estimate is more in agreement with the SN 1987A prediction. SN 2005ip grow over time, as has been observed in SN 1987A and other CCSNe would be similar to SN 1987A.