

## Dust in a Type Ia Supernova Progenitor: Spitzer Spectroscopy of Kepler's Supernova Remnant

Brian J. Williams,<sup>1,2</sup> Kazimierz J. Borkowski,<sup>1</sup> Stephen P. Reynolds,<sup>1</sup> Parviz Ghavamian,<sup>3</sup>  
William P. Blair,<sup>4</sup> Knox S. Long,<sup>5</sup> Ravi Sankrit<sup>6</sup>

### ABSTRACT

Characterization of the relatively poorly-understood progenitor systems of Type Ia supernovae is of great importance in astrophysics, particularly given the important cosmological role that these supernovae play. Kepler's Supernova Remnant, the result of a Type Ia supernova, shows evidence for an interaction with a dense circumstellar medium (CSM), suggesting a single-degenerate progenitor system. We present 7.5–38  $\mu\text{m}$  IR spectra of the remnant, obtained with the *Spitzer Space Telescope*, dominated by emission from warm dust. Broad spectral features at 10 and 18  $\mu\text{m}$ , consistent with various silicate particles, are seen throughout. These silicates were likely formed in the stellar outflow from the progenitor system during the AGB stage of evolution, and imply an oxygen-rich chemistry. In addition to silicate dust, a second component, possibly carbonaceous dust, is necessary to account for the short-wavelength IRS and IRAC data. This could imply a mixed chemistry in the atmosphere of the progenitor system. However, non-spherical metallic iron inclusions within silicate grains provide an alternative solution. Models of collisionally-heated dust emission from fast shocks ( $> 1000 \text{ km s}^{-1}$ ) propagating into the CSM can reproduce the majority of the emission associated with non-radiative filaments, where dust temperatures are  $\sim 80\text{--}100 \text{ K}$ , but fail to account for the highest temperatures detected, in excess of 150 K. We find that slower shocks (a few hundred  $\text{km s}^{-1}$ ) into moderate density material ( $n_0 \sim 50\text{--}100 \text{ cm}^{-3}$ ) are the only viable source of heating for this hottest dust. We confirm the finding of an overall density gradient, with densities in the north being an order of magnitude greater than those in the south.

---

<sup>1</sup>Physics Dept., North Carolina State University, Raleigh, NC 27695-8202

<sup>2</sup>NASA Goddard Space Flight Center, Greenbelt, MD, 20771; brian.j.williams@nasa.gov

<sup>3</sup>Towson University, Dept. of Phys., Astronomy, and Geosciences, Towson, MD 21252

<sup>4</sup>Dept. of Physics and Astronomy, Johns Hopkins University, 3400 N. Charles St., Baltimore, MD 21218-2686.

<sup>5</sup>STScI, 3700 San Martin Dr., Baltimore, MD 21218.

<sup>6</sup>SOFIA/USRA