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What is Nature Telling Us About Thermonuclear Supernovae?gv

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Thermonuclear (Type Ia) supernovae (SNe) have become the premier tools for measuring the distances to high-redshift galaxies. A decade ago they played the key role in the discovery of the accelerating expansion of the universe and the implied "dark energy" which apparently dominates the mass-energy density of the current universe. However, to move beyond the detection of cosmic acceleration to study its dynamic evolution requires a dramatic increase in the accuracy of supernova distance measures which are currently limited by an intrinsic uncertainty of $\sim 10\%$. Measuring distances with Type Ia supernovae has, for the most part, been an entirely empirical business. Furthermore, while there is general consensus on the basic theory of thermonuclear supernova explosions, the details of this picture are still the subject of much discussion. Many of these details can induce subtle shifts in the implied SN distance. So understanding (or at least constraining) these effects is crucial if we are to dramatically increase the accuracy of SN Ia distances. I will present results from several studies using new observational tools (most prominently infrared spectroscopy) to provide new constraints on our understanding of the details of thermonuclear supernova explosions. Generally these programs are revealing that the expanding supernova ejecta have a highly chemically layered structure. Such layering suggests a detonation scenario for the propagation of nuclear burning. However, the currently popular detonation scenarios all involve an early period of slow burning prior to detonation, and tend to predict a chemically turbulent region in the inner-most ejecta. However the observations seem imply that the chemical layering persists even in the earliest burning stages. Explaining this discrepancy will be a key test of future SN Ia explosion models.