A More General Model for the Intrinsic Scatter in Type Ia Supernova Distance Moduli

John Marriner, J.P. Bernstein, Richard Kessler, Hubert Lampeitl, Ramon Miquel, Jennifer Mosher, Robert C. Nichol, Masao Sako, Donald P. Schneider, Mathew Smith

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We describe a new formalism to fit the parameters α and β that are used in the SALT2 model to determine the standard magnitudes of Type Ia supernovae. The new formalism describes the intrinsic scatter in Type Ia supernovae by a covariance matrix in place of the single parameter normally used. We have applied this formalism to the Sloan Digital Sky Survey Supernova Survey (SDSS-II) data and conclude that the data are best described by $\alpha=0.135_{-.017}^{+.033}$ and $\beta=3.19_{-0.24}^{+0.14}$, where the error is dominated by the uncertainty in the form of the intrinsic scatter matrix. Our result depends on the introduction of a more general form for the intrinsic scatter of the distance moduli of Type Ia supernovae than is conventional, resulting in a larger value of β and a larger uncertainty than the conventional approach. Although this analysis results in a larger value of β and a larger error, the SDSS data differ (at a 98% confidence level) with $\beta=4.1$, the value expected for extinction by the type of dust found in the Milky Way. We have modeled the distribution of supernovae Ia in terms of their color and conclude that there is strong evidence that variation in color is a significant contributor to the scatter of supernovae Ia around their standard candle magnitude.

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