

# Dust Attenuation and Type Ia Supernova Host Bias

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## 1. PERSONNEL

We request support for graduate student Jared Hand and one undergraduate student under Professor Michael Wood-Vasey at the University of Pittsburgh for our project exploring the relationship between host galaxy dust effects and the measurement of the type Ia supernova (SN Ia) host bias. Graduate student Hand, using this support to cover a gap in funding, will build the proposed project's foundations:

- Developing a proper hierarchical Bayesian model with the statistics programming language Stan<sup>1</sup> for our proposed project.
- Deploying a SQLite database and interact with it using SQLAlchemy<sup>2</sup>.
- Developing a framework to properly integrate differing galaxy dust attenuation corrections into our analysis and interpreting their impact.

With Professor Wood-Vasey in support, graduate student Hand will work closely with the undergraduate in developing the following skills:

- Scalable, project-oriented, and data-driven programming techniques using Python and github.
- Bayesian statistics using a hands-on approach with astronomical data.
- Introductory relational database querying using a local project SQLite database.

Data-driven analysis skills will be developed through manipulation of large SN Ia data sets presented within the context of LSST's science goals. Both mentors will prepare the undergraduate's presenting of their work to DESC or PCW, providing the undergraduate with practice in science communication and giving exposure to the LSST science community. Graduate student Hand similarly will present project results to DESC or PCW.

## 2. PROPOSED PROJECT

The Vera C. Rubin Observatory will provide an order of magnitude increase in observed SNe Ia, dramatically improving these objects' ability to constrain fundamental cosmological constants such as the Hubble constant and the dark energy equation of state (Perlmutter et al. 1999). SNe Ia are standardizable — correlations between peak brightness and both color and SN duration are used to reduce the low intrinsic scatter in peak brightness of these objects. Though the effects of foreground host galaxy dust simultaneously diminish a SN Ia's peak brightness and redden its spectrum, this dust-only model does not account for all SN Ia color variation (Brout & Scolnic 2021). There is also an established bias

<sup>1</sup> <https://mc-stan.org/>

<sup>2</sup> <https://www.sqlalchemy.org/>

between SN Ia properties and the properties of its host galaxies propagate through SN Ia standardization procedure, the most studied being the mass step (Sullivan et al. 2010). Similarly biased host properties such as stellar age and star formation rate (SFR) are strongly degenerate with host dust properties, with recent studies finding in linear combination of stellar age or SFR with host stellar mass better accounting for both the observed host bias and its propagation through standardization (Rigault et al. 2020; Rose et al. 2021). Brout & Scolnic (2021) has also found that a more sophisticated dust model for SNe Ia removes the host bias during standardization. An exploration into the effects of host dust correction on the measured host bias would bridge a gap in knowledge between SN Ia color variation due to dust and the effects of dust on the measured host bias. Such a project would specifically determine if dust attenuation modeling influences or removes the host bias while exploring the relationship between dust attenuation and star formation epoch within the context of SN Ia standardization.

Our project is a continuation of recent the analysis from the Wood-Vasey group into the influence of observation and fitting techniques into SN Ia host bias measurements (Hand et al. 2021). Using Integral Field Spectrum (IFS) observations and data products from both the PISCO (Galbany et al. 2018) and AMUSING<sup>3</sup> SN Ia host samples alongside overlapping ultraviolet (UV) surveys, we will compare specific SFR (sSFR) calculations from global and resolved H $\alpha$  flux and UV photometry. Said sSFR estimates will be calculated with and without host galaxy dust attenuation corrections. sSFR is a natural host property to explore given its intrinsic nature, differing observables that trace differing epochs of star formation, and by definition being a linear combination of host properties:  $\log(sSFR) = \log(SFR) - \log(Mass)$ . Along with the commonly used H $\alpha$ /H $\beta$  ratio correction, more sophisticated dust attenuation models from Salim et al. (2018) and Narayanan et al. (2018) will be implemented and compared. All this work will be performed within hierarchical Bayesian framework implemented with Stan to appropriately account for covariance in physical and latent parameters inherent to such an analysis.

## REFERENCES

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| <p>Brout, D., &amp; Scolnic, D. 2021, ApJ, 909, 26,<br/>doi: <a href="https://doi.org/10.3847/1538-4357/abd69b">10.3847/1538-4357/abd69b</a></p> <p>Galbany, L., Anderson, J. P., Sánchez, S. F.,<br/>et al. 2018, ApJ, 855, 107,<br/>doi: <a href="https://doi.org/10.3847/1538-4357/aaaf20">10.3847/1538-4357/aaaf20</a></p> <p>Hand, J., Liu, S., Galbany, L., et al. 2021,<br/>arXiv e-prints, arXiv:2102.08980.<br/><a href="https://arxiv.org/abs/2102.08980">https://arxiv.org/abs/2102.08980</a></p> <p>Narayanan, D., Conroy, C., Davé, R.,<br/>Johnson, B. D., &amp; Popping, G. 2018, ApJ,<br/>869, 70, doi: <a href="https://doi.org/10.3847/1538-4357/aaed25">10.3847/1538-4357/aaed25</a></p> <p>Perlmutter, S., Aldering, G., Goldhaber, G.,<br/>et al. 1999, ApJ, 517, 565,<br/>doi: <a href="https://doi.org/10.1086/307221">10.1086/307221</a></p> | <p>Rigault, M., et al. 2020, Astron. Astrophys.,<br/>644, A176,<br/>doi: <a href="https://doi.org/10.1051/0004-6361/201730404">10.1051/0004-6361/201730404</a></p> <p>Rose, B. M., Rubin, D., Strolger, L., &amp;<br/>Garnavich, P. M. 2021, ApJ, 909, 28,<br/>doi: <a href="https://doi.org/10.3847/1538-4357/abd550">10.3847/1538-4357/abd550</a></p> <p>Salim, S., Boquien, M., &amp; Lee, J. C. 2018,<br/>ApJ, 859, 11,<br/>doi: <a href="https://doi.org/10.3847/1538-4357/aabf3c">10.3847/1538-4357/aabf3c</a></p> <p>Sullivan, M., Conley, A., Howell, D. A., et al.<br/>2010, MNRAS, 406, 782,<br/>doi: <a href="https://doi.org/10.1111/j.1365-2966.2010.16731.x">10.1111/j.1365-2966.2010.16731.x</a></p> |
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<sup>3</sup> <https://amusing-muse.github.io/publications/>