Dust Attenuation and Type Ia Supernova Host Bias

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ABSTRACT

Building on our research group's past work on the type Ia supernova (SN Ia) host bias, we wish to supplement graduate student Jared Hand and fund an undergraduate in a project studying dust attenuation correction techniques influence on SN Ia host bias corrections and its connection to SN Ia color variation. Better understanding SN Ia color variation and characteristics of the host bias will improve the utility of SN Ia for measuring dark energy.

- $10,000 requested

1. PERSONNEL AND PROPOSED PROJECT

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 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[1] for our proposed project.
- Deploying a SQlite database and interact with it using SQLAlchemy[2].
- 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, 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. Graduate student Hand and the undergraduate will both present project results and their respective contributions to DESC and

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[1] https://mc-stan.org/
[2] https://www.sqlalchemy.org/

PCW, providing practice in science communication and exposure to the LSST science community. This project builds upon graduate student Hand's prior research and will contribute towards their final dissertation.

SN Ia peak brightnesses are standardized using correlations between peak brightness and both color and explosion duration to reduce the naturally low scatter in peak brightness. There is also an established bias between SN Ia properties and the properties of its host galaxies that propagates through SN Ia standardization procedure, resulting in the well-studied mass step (Sullivan et al. 2010). Studies have found that linear combinations of stellar age or star formation rate (SFR) with stellar mass better account for both the observed host bias and its propagation through standardization (Rigault et al. 2020; Rose et al. 2021). Stellar age and SFR are strongly degenerate with host dust properties, though, and Brout & Scolnic (2021) found that although SN Ia color is not entirely explained by a dust-only model, a more sophisticated standardization model incorporating host dust effects accounts for the mass step. We propose exploring the effects of host dust correction techniques on the measured host bias to help bridge a gap in knowledge between SN Ia color variation from dust and the effects of dust on the host bias.

We took a first step in understanding the influence of observation and fitting techniques on SN Ia host bias measurements in Hand et al. (2021) using the Integral Field Spectra (IFS) observations of PISCO SN Ia host sample (Galbany et al. 2018). This proposed project will triple our prior statistics by including AMUSING (Galbany et al. 2016) and instead will focus on host galaxy dust attenuation's effects on differing SFR tracers. Using PISCO with the higher resolution AMUSING IFS SN Ia host samples alongside overlapping UV surveys, we will compare specific SFR (sSFR) estimates from Hα flux and UV photometry both with and without dust attenuation corrections. sSFR is a natural host property to explore given its intrinsic nature, with different observables (Hα and UV flux) that trace differing epochs of star formation and by it being a linear combination of host properties: $\log \mathrm{sSFR} = \log \mathrm{SFR} - \log \mathrm{Mass}$. Along with the Balmer decrement Hα/Hβ correction, we will implement and compare sophisticated dust attenuation models from Salim et al. (2018) and Narayanan et al. (2018). A hierarchical Bayesian framework implemented with Stan will be used to study the effects of differing attenuation techniques on standardization.

2. BUDGET NARRATIVE

We request $5000 each in funding for graduate student Hand and an undergraduate to supplement their stipends. We wish to disburse funds directly to our institution, which has an administrative fee.

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