Extragalactic Supernova Observations and Correlation of Frequency with Galaxy Age

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Abstract: Supernovae may be a reliable resource for predicting the ages of galaxies. Young galaxies may have a lower population of old stars and therefore be less likely to experience supernova events. This correlation could allow us to determine the age of galaxies more accurately. I propose to observe a group of diverse galaxies over a period of at least a year to expand our understanding of which galaxies experience supernova events more often, and whether certain properties, especially age, contribute to this difference in frequency.

Scientific Justification

Just as supernovae clearly indicate a certain stage in the life of a star, they may also be able to help determine the age of the galaxies that contain them. Estimates of the supernova frequency in the Milky way range from ~2.5[1] to 5.7±1.7[2] supernova events per 100 years. This should have given us plenty of opportunities since the advent of the telescope to observe supernovae as they appear and then evolve, however, supernovae in the Milky way have been directly observed just a fraction of the number of times they have theoretically occurred. With much of the galaxy obscured by dust and stars [3], it is difficult to accurately measure the true frequency of supernovae within our own galaxy. This makes it difficult to study supernova events, as the source can rarely be observed throughout the entire duration of the event. Observing extragalactic supernovae, however, can be much easier, as we are able to view other galaxies at a much more favorable inclination.

Observing several neighboring and more distant galaxies over a long period of time will enable us to observe any supernovae that occur during our observations and watch the evolution of the supernova from the very beginning. Looking further into the future, this data could allow us to draw more conclusions regarding what determines the frequency of supernovae and how to predict the frequencies of supernova events in other galaxies. One possible conclusion, and the one I am most interested in, may be some correlation between galaxy age and supernova frequency.

G.A. Tammann et al. (1994) found a correlation between galaxy type and the frequency of supernovae, with type Scb-Sd and Sdm-Im type galaxies having significantly higher supernova rates than other types. van de Sande, J et al. (2018) found a correlation between galaxy age, stellar population age, and galaxy morphology, meaning there is likely a conclusion to be drawn relating the age of a galaxy to the frequency of supernovae within it.

Any galaxies could be chosen for these observations. It would be preferrable to choose galaxies with small inclinations minimizing the number of supernovae being blocked from view by other parts of the galaxies. It would also be convenient to choose galaxies, with a diverse range of Right Ascensions, allowing the observation of different galaxies throughout the year to maximize the amount of data collected. A galaxy will brighten significantly if a supernova event is taking place within it, making recognizing the event relatively simple.

Any conclusion that may be drawn from these observations could significantly increase our understanding of not only how other galaxies evolve along with the stars they contain but could also help us better understand the Milky Way, how it came to be in its current form, and what the future might hold for it.

Technical Justification

I propose weekly observations over a period of a year or more using the MSU Observatory's 24-inch telescope to observe of each of our targets. Using the MSU observatory, observing the targets should be relatively trivial, as there are many bright galaxies observable from East Lansing throughout the year. Each target will be observed using a V band filter, with 20-minute exposures each per observing night. Assuming roughly 10 observable targets on a given night, this is 20 minutes × 10 targets = 3.33 hours per night. One 4-hour long observation night per week over a period of 52 weeks equates to 208 total hours of telescope time. Assuming a supernova rate between 2.5 and 7.4 supernova events per century and 10 galaxies observed at a time, I would expect to observe between 0.25 and 0.74 supernovae per year of weekly observation. This number could be increased by either observing more galaxies per night or observing over a longer period of time.

Potential Target List:

Galaxy	*RA*	*Dec*	*V*	*Constellation*
M31	0h42m44.3s	41°16'9"	3.44±0.03	Andromeda
M33	1h33m50.02s	30°39'36.7"	5.72	Triangulum
M81	9h55m33.2s	69°3'55"	6.94	Ursa Major

Figures:

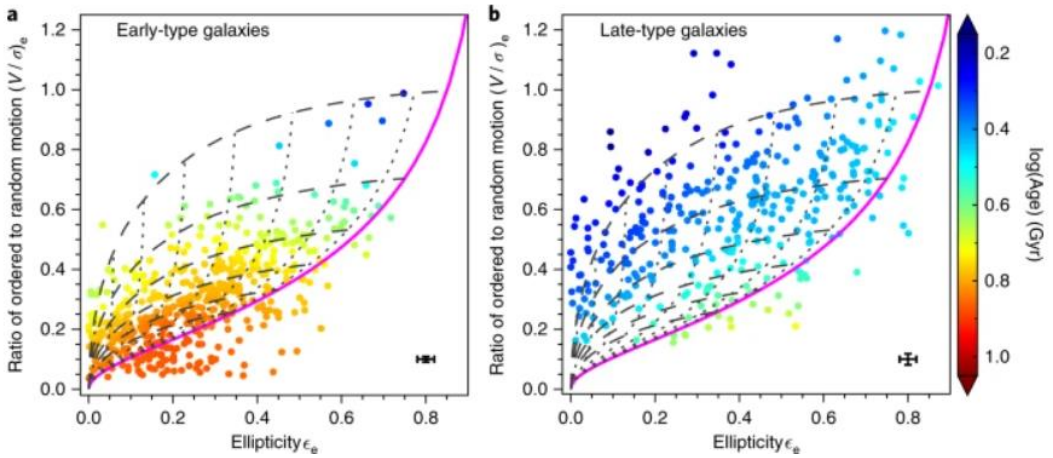

Figure 1: Figure 3 from van de Sande, J. et al. (2018) showing a relation between galaxy type, star population age, and galaxy morphology.

Supernova Type	Galaxy Type				
	E-S0	S0/a-Sa	Sab-Sb	Sbc-Sd	Sdm-Im
All types	0.07	0.05	0.15	0.37	0.40
Ia	0.07	0.035	0.035	0.035	0.035
Ib	...	0.003	0.019	0.06	0.06
II	...	0.012	0.096	0.275	0.30

Figure 2: Table 1 from Tammann G. A. et al. (1994) showing the relative rates of supernovae in different types of galaxies, with Sbc-Sd and Sdm-Im type galaxies experiencing significantly more supernova events than the other types listed. This relationship coupled with that found by van de Sande, J et al. may indicate a relationship between galaxy age and supernova rate.

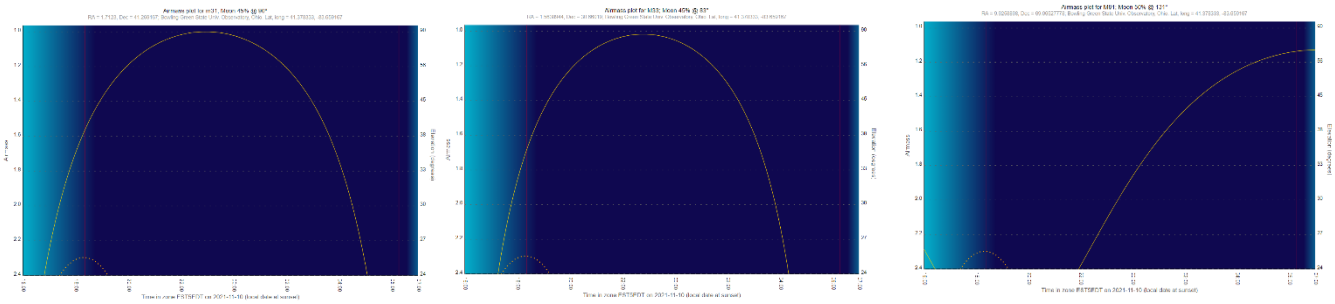

Figure 3: Airmass graphs for my possible targets M32, M33, and M81 on a November night. I can choose several more galaxies with varying Right Ascensions to allow us to observe throughout the entire proposed year.

References:

[1]: Tammann G.~A., Loeffler W., Schroeder A., 1994, The Galactic Supernova Rate, ApJS, 92, 487

[2]: Strom R.~G., 1994, “Guest Stars”, sample completeness and the local supernova rate, A&A, 288, L1

[3]: Scott M. Adams *et al* 2013, Observing the Next Galactic Supernova, *ApJ* **778** 164

[4]: van de Sande, J., Scott, N., Bland-Hawthorn, J. *et al.* A relation between the characteristic stellar ages of galaxies and their intrinsic shapes. *Nat Astron* **2,** 483–488 (2018). https://doi.org/10.1038/s41550-018-0436-x