Modeling the Light Curve of a Type IIp SuperNova

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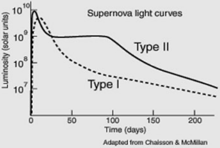
Supernovae are the result of an explosion of a supergiant star (minimum 8, but no more than 50 times the mass of our sun). There are two classifications of Supernovae (SNe): Type I, specifically Type I-A, often referred to as Standard Candles, which is an accurate method to measure distance in Astronomy. Type II, known as core collapse, which have more diversity in their luminosities than Type I. This makes them easily mistakable for Type Ia, so distinguishing easily between the two is important to prevent contamination issues.

This photo is of the NGC 4526 Galaxy, the bright spot in the lower left corner is a type I-A supernovae named 1994D.
Photo from http://en.wiki.org/wiki/Supernovae

Purpose

Type I-A SNe are the most reliable astronomical objects to measure relative distances. Research in this area has shown the expansion of the Universe. It is not only expanding but accelerating which leaves many more questions than answers. Type II-P SNe are less studied because their variation makes them hard to distinguish and also troublesome when mistaken for Type I-A. With constant technological advances that allow for increased observations, like the Large Synopitc Survey Telescope (LSST), there will soon be more data than can be managed and this research optimizes cost and time efficiency.

Photo from http://hyperphysics.phy-astr.gsu.edu/hbase/astro/snovcn.html



Graph from http://hyperphysics.phy-astr.gsu.edu/hbase/astro/snovcn.html

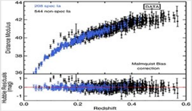
Research Methods

Through the summer I have worked under the guidance of Dr. Peter Garnavich to develop a modeling function to fit the light curves of SNII-P starting with the well sampled Kepler Space Telescope observation of KSN2011d.

Python is the computer language I used to code the various functions that fit the light curve.

The following are the main functions combined to fit the curve:

Fermi-Dirac Function **Least Square Function**
Chi Square Function **Gaussian Function**



References

1. Felipe Olivares E., et. al. The Astrophys. J. 2010, 715:833-853
2. P.M. Garnavich, et. al. Astrophys. J. 2016, 820:1-7
3. Hyperphysics.phy-astr.gsu.edu

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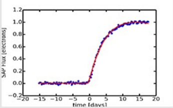
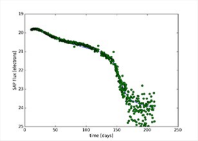
Modeling the Light Curve

As illustrated below, Type II-P SNe have a more complex light wave and it requires a combination of functions to fit the various peaks and decays. The initial ris is best fit using a physically motivated model of Rabinak & Waxman. After maximum, a half-Gaussian Function matches the decline down to the "plateau phase". A Fermi-Dirac Function is used to fit the plateau and the fast decline after the plateau and finally a linear decay is used to model the radioactive decay at the late-times.



Conclusions

The optimal reduced Chi Square value is 1. The initial rise a reduced Chi Square value of 1.8 was reached. Olivares et. al. obtained a 1.5 in their research. While my value is not optimal and has room for improvement the fit itself appears to be well represented on the above plot and the fitting of the declining light curve is on-going and represented below



The above plot is of the decay portion of the Type IIp SN, which is where the decay occurs. This is the beginning stages of development.