Most massive stars will end their life with a violent explosion known as a core collapsing supernova. ~99% of the supernova’s energy comes from neutrinos. These neutrinos will escape the core collapse before any photons and can give the time and direction of the explosion. Therefore, supernova neutrinos can serve as an early warning signal to astronomers. At present, there have only been approximately 20 neutrinos detected from supernovae, which all originated from SN1987A. Larger telescopes and detectors are currently being constructed that will increase the chance of finding neutrinos. Our goals of this project are to estimate the number of neutrinos from the All Sky Automated Survey for SuperNovae (ASAS-SN), and the Zwicky Transient Facility (ZTF) at the Hyper-Kamiokande (HK) detector, and predict the number of supernovae the Legacy Survey of Space and Time (LSST) will detect over a range of distances with the hopes of determining the best range of time and distance to find neutrinos.

Core Collapse

Core collapse supernova are classified as types II, Ib, and Ic. A core collapse supernova happens when a star with a mass > 8 M☉ begins to fuse heavy elements in the star’s core. Eventually, the core will try to fuse iron into heavier elements but will fail and cause the core to become so dense that it will collapse in on itself. During this process, thousands of neutrinos are produced through many ways such as electron capture.

\[ \text{electron capture} \quad \nu_e + p \rightarrow n + \text{e}^- \]

Neutrinos are then trapped and the core forms into a massive nucleus. This massive nucleus creates a shock wave that expands the core and releases neutrinos. Soon after the expansion, the shock wave will become stagnant, then turn into an accretion shock. During this phase, neutrinos react with protons and neutrons creating a massive amount of energy. This energy causes a shock revival, where the shock wave begins to expand outwards again. This shock wave results into a supernova.

FIG. 1: SN1987A

Our neutrino estimations for ASAS-SN and ZTF show promising outcomes because they are much higher than we anticipated. In the future, we hope to better estimate the number of supernovae LSST will detect each year, which will lead to better neutrino estimations. Furthermore, we want to better examine the neutrino background rate LSST would experience. This would lead to determining the best strategy to find neutrinos.

REFERENCES

I would like to thank Dr. Shunsaku Horiuchi and Sean Heston for their help and support throughout this project. The work of Emily Kehoe was supported by the National Science Foundation.