CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

**Name(s)**
Avi S. Patel

**Project Number**
**S1816**

**Project Title**
# A Study of the Variation of Metallicities in Galaxy Clusters with Relation to their Morphologies

**Abstract**

**Objectives/Goals**
Galaxy clusters are celestial laboratories to study the evolution of the universe. The intracluster medium within galaxy clusters hosts an array of metallicities, like iron (Fe) and nickel (Ni), that can be analyzed through x-ray emission spectra. The goal of this research is to identify a correlation between the cluster abundances of Fe and Ni in relation to galaxy cluster substructures.

**Methods/Materials**
I used x-ray spectroscopy to analyze Fe and Ni abundances in galaxy clusters. I obtained a sample of 32 galaxy clusters with a redshift range $0.02 < z < 0.3$ from the Chandra X-ray telescope that have corresponding values for morphology parameters in Parekh et. al 2015. Through using the Chandra X-ray Observatory's Ciao Tools and SAOImage DS9, I created a thermal plasma emission model with a Bremsstrahlung Continuum model to obtain the abundances of Fe and Ni. Subtle inaccuracies in the galaxy cluster point source extraction required filtering the abundance data by correlating its temperature vs. abundance with Baumgartner et. al 2005. I then correlated the data with the updated morphology parameters (Gini coefficient, Moment of Light, and Concentration) in Parekh et. al 2015 using Microsoft Excel.

**Results**
After filtering the Fe and Ni abundance data, I developed three correlations between abundance data and each morphology parameter. After dividing data by dynamical state of the cluster, I found a correlation between each parameter and the Fe and Ni abundances for the non-relaxed clusters concluding that as a galaxy cluster becomes more disturbed in substructure, the Fe and Ni abundances increase.

**Conclusions/Discussion**
These galaxy clusters abundance and morphology correlations were expected based on the cluster cooling time simulations from Parekh et. al 2015. Applying my abundance data to these cooling time simulation results, they suggest that as the cooling times increase for these clusters, the Fe and Ni abundances also increase. This asserts that as galaxy clusters mature, processes, such as star formation and supernovae, also occur producing heavier elements such as Fe and Ni.

**Summary Statement**
By using x-ray spectroscopy to obtain galaxy cluster Fe and Ni abundances and relate them to cluster morphologies, this research concludes that Fe and Ni abundances correlate with galaxy cluster substructure parameters.

**Help Received**
Mrs. Messenger and Mr. Burns guided me through the research process and provided feedback.