LA-UR-17-26420
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Title: Automated Blazar Light Curves Using Machine Learning

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Intended for: Talk at Internal Meeting
Report

Issued: 2017-07-27

# Automated Blazar Light Curves Using Machine Learning

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# Personal Background

- Post-Master’s Student in Mathematical Physics from the University of Cambridge
- Preparing for PhD in Physics at UIUC.
- Came to LANL to get experience with data analysis and experimental hardware.

# Background on Problem

- Blazars are a type of active galactic nucleus which emit relativistic jets in line with the Earth.
- Blazars emit outbursts of energy across the electromagnetic spectrum.

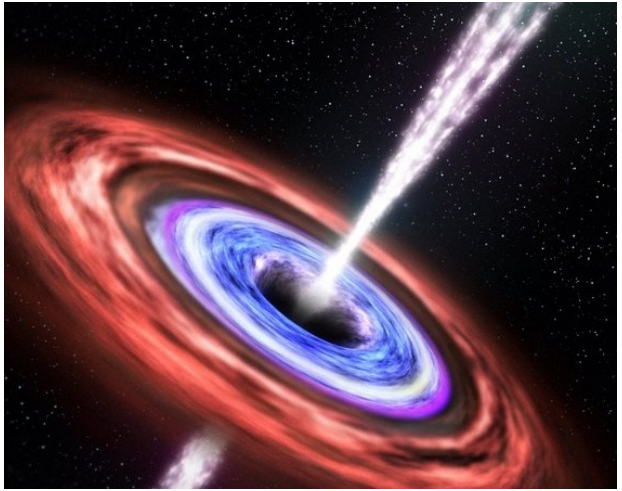
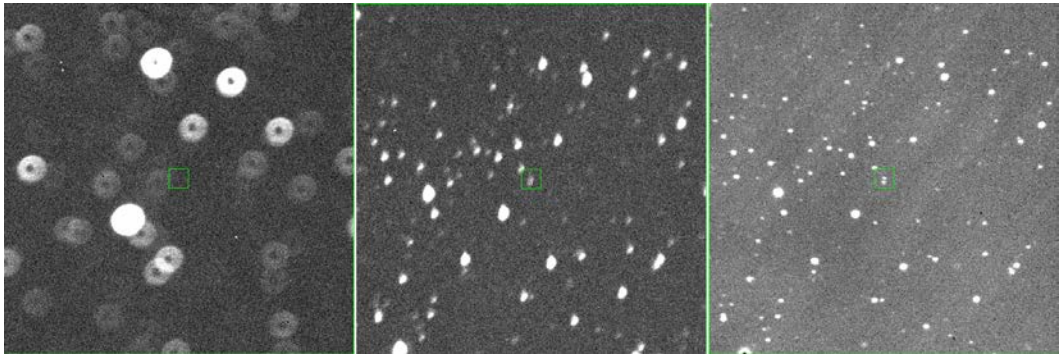


Image courtesy of NASA/Goddard Space Flight Center

  - Most bursts occur at gamma ray and optical energies simultaneously, but there are “gamma-ray orphans,” in which a simultaneous optical burst is not present.
  - Different models of blazar emissions have different predictions for these orphans.

# Problem Addressed



- Investigating the optical variability patterns for blazars tracked by the RAPTOR-S telescope requires the construction of light curves.
- In order to generate these light curves, data must be filtered before processing to ensure quality.

# Methodology

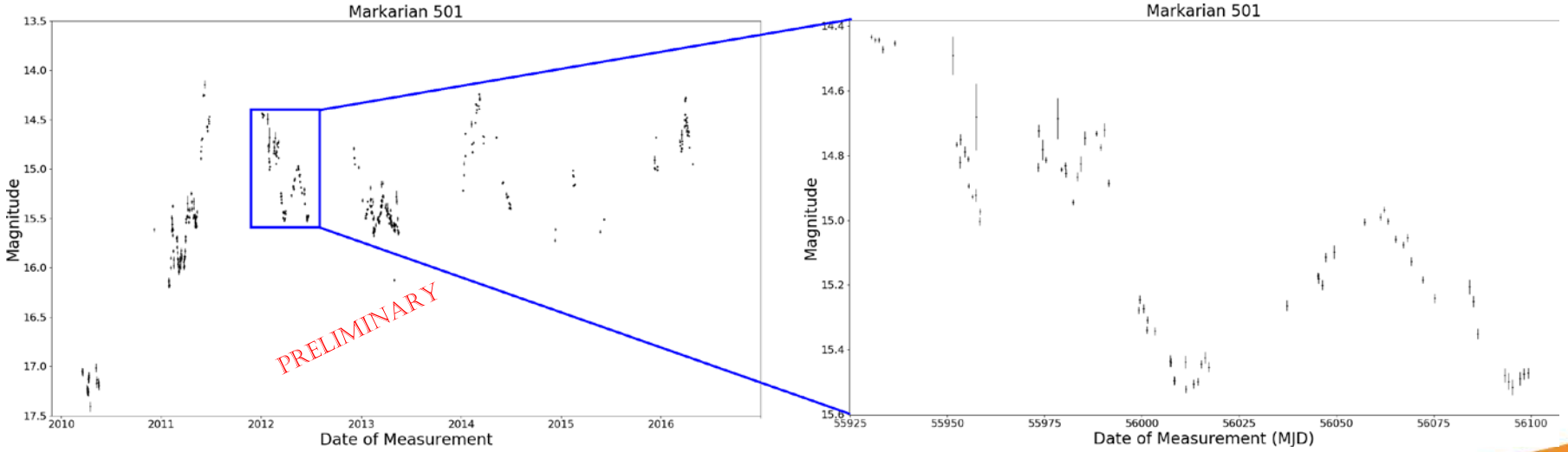
- Designed 3-step quality filter system for blazar images.
  - *Coarse filtering using object lists and background brightness*
  - *Calibration of uncalibrated data using astrometry.net*
  - *There layer convolutional neural network trained with ~5000 labeled images.*
- Implemented automated IRAF photometry pipeline to extract light-curves from filtered images

# The Neural Network

- Network uses two convolutional/pooling layers, and a single fully connected layer.
- Input is a 28x28 greyscale image of the object's surroundings.
- Sizes were tested from 8x8 pixels to the entire 1024x1024 image, with multiple binning schemes.
- Robustness of network was tested across three different labeling methods and the injection of junk data.
- System achieved screening accuracy of 99% on validation data.

# Conclusions

- Example light curve generated by system.



# Future Work

- Future Work:
  - Detailed validation of photometric measurements.
  - Generate light curves for the entire RAPTOR-S Blazar database.
  - Implement system for blazar variability tracking.