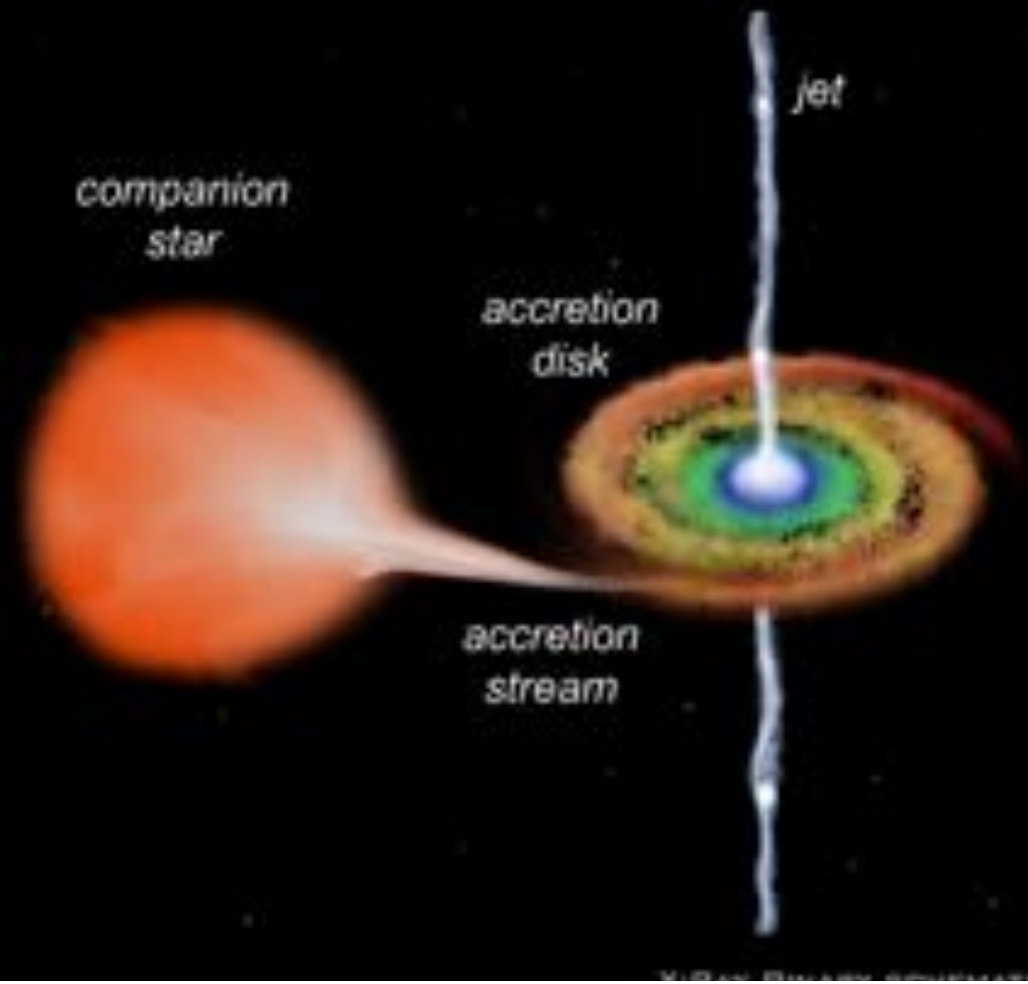
4th Year Research Projects, 2017/2018

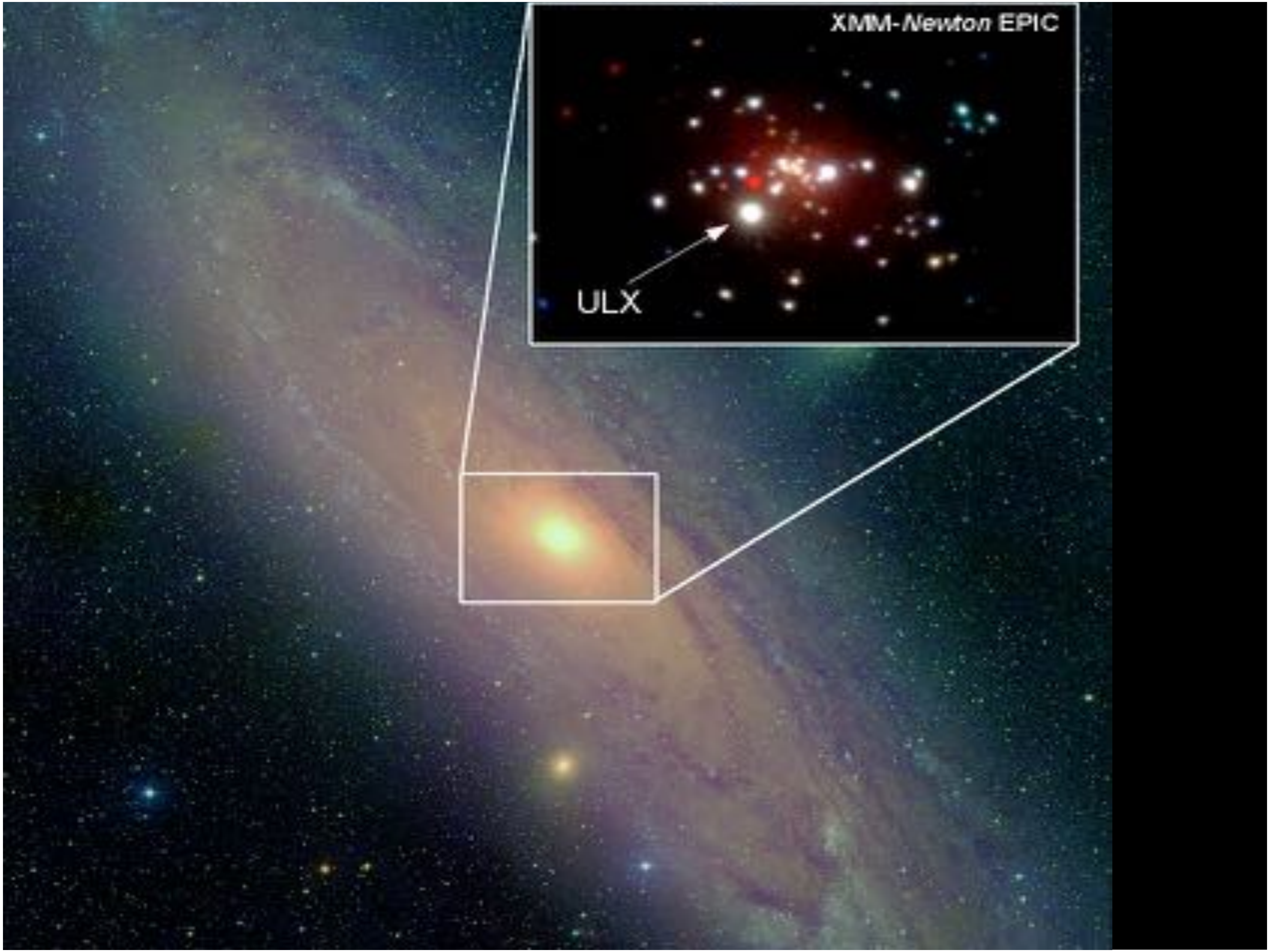


Prof Paul Callanan

Project 1: X-ray and optical observations of dynamically formed ultra compact binaries [long]

In the cores of dense globular clusters and galaxies, the number of stars per unit volume is such that they scatter off each other, sometimes merging, or forming binary systems. When one of the stars is a compact object (black hole, neutron star or white dwarf), the binaries become visible as bright X-ray (1-10 kev) emitters.

X-ray image (0.5-10 keV) of a globular cluster


XMM-Newton EPIC
ULX

The student will:

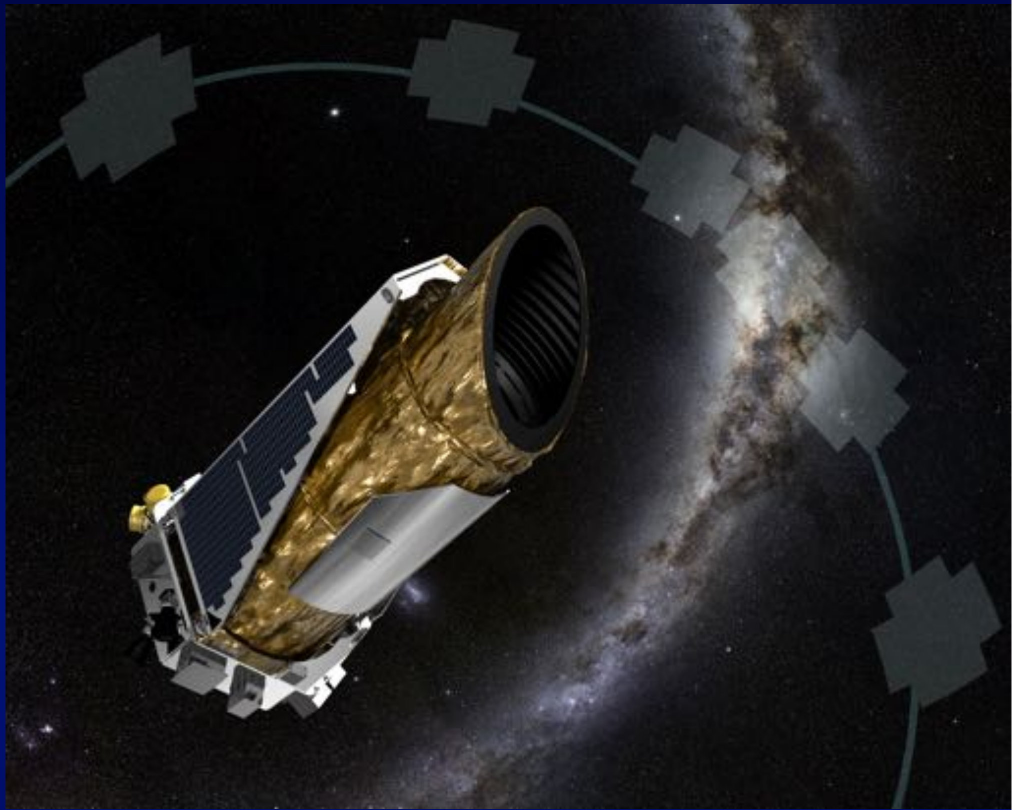
- Analyze Chandra X-ray images of globular clusters (e.g. Omega Cen, M22 and 47 Tuc), and perform the astrometry required to localize the positions to within < 0.5''.
- Relate these measurements to HST observations of the same field, identifying optical counterparts to the X-ray sources on the basis of their spectral energy distribution and variability.

The HST observations are required because of the very crowded nature of these fields.

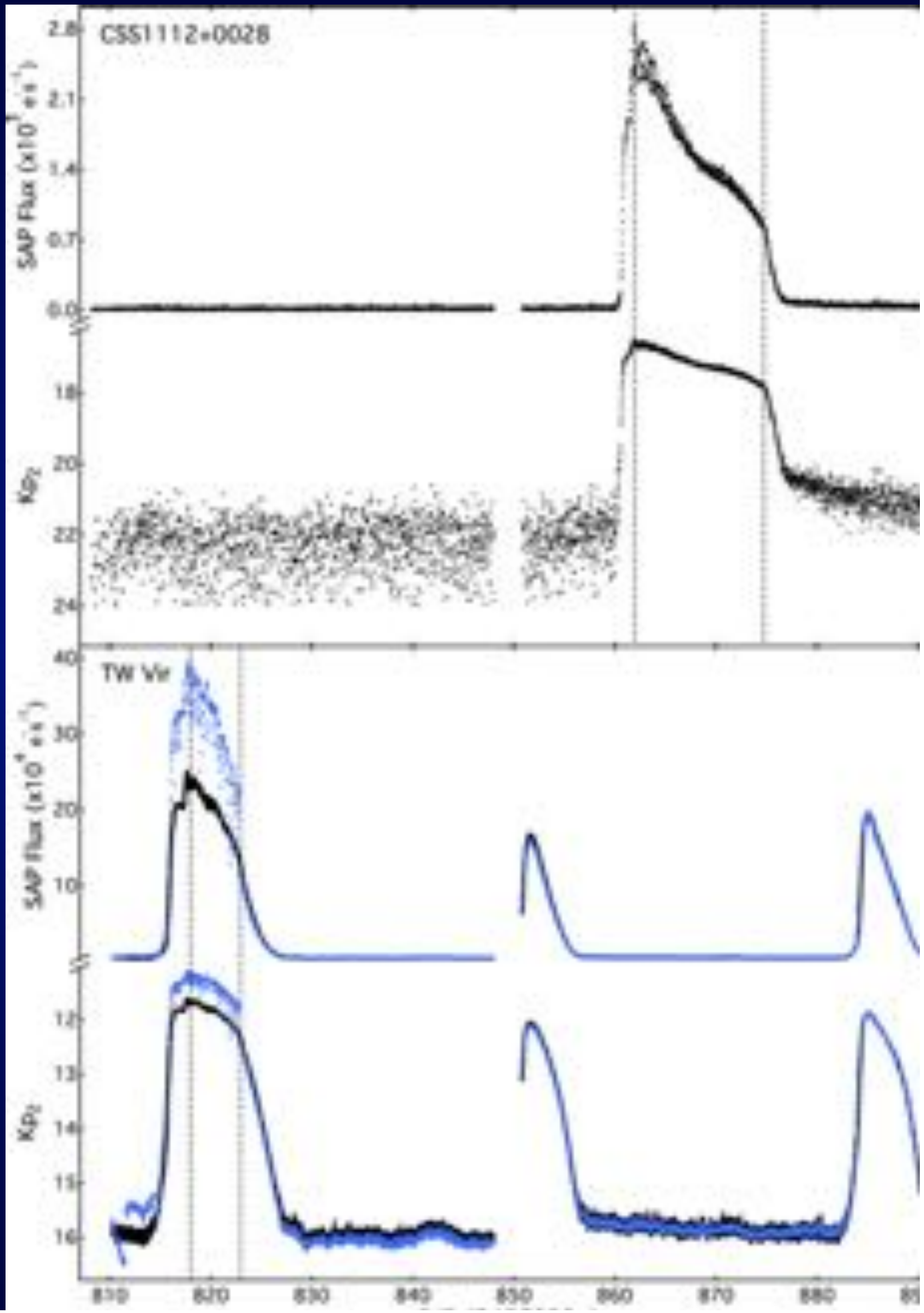
These measurements will allow us to identify new white dwarf, neutron star systems, and address the existence of black holes in globular clusters.

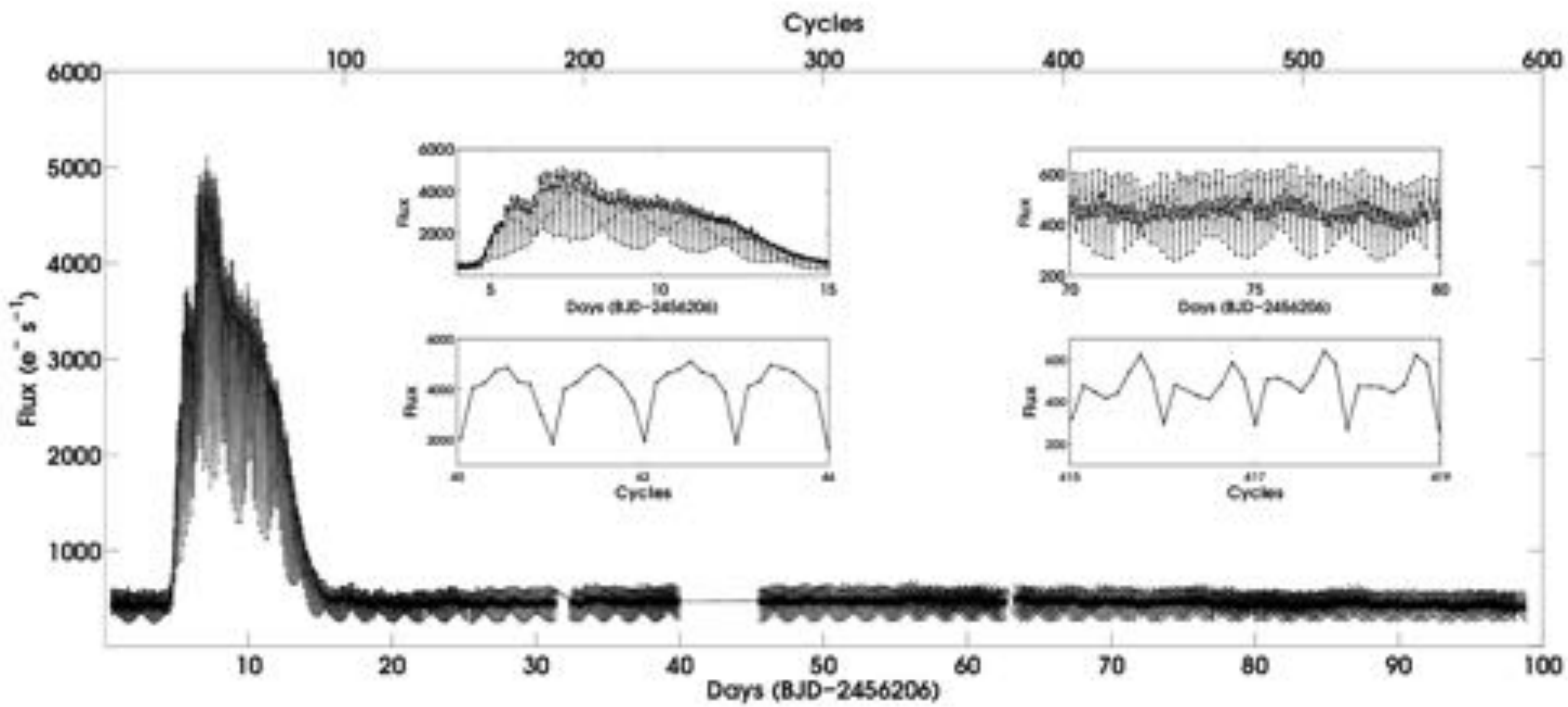
Project 2: Kepler photometry of Cataclysmic Variables.

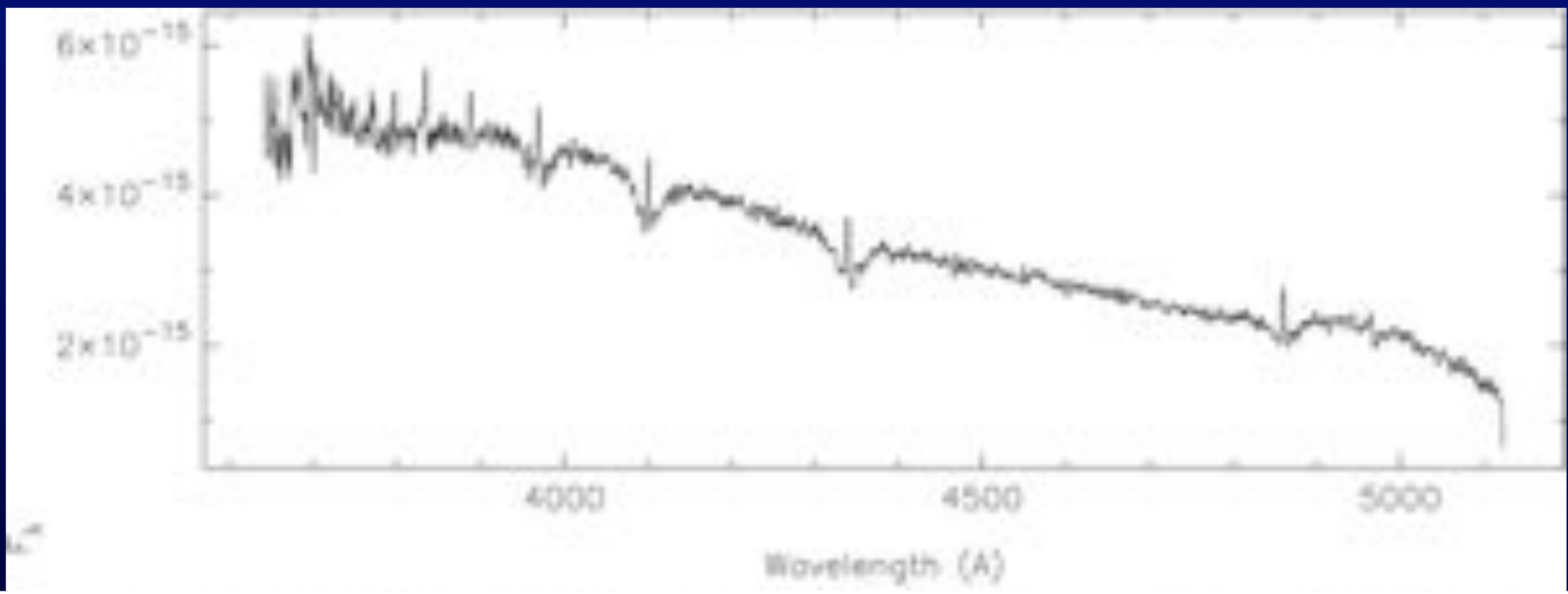
The Kepler K2 mission has allowed for continuous monitoring of many fields around the ecliptic, with a photometric accuracy ~100 times better than possible from the ground. Since Campaign 5 of the K2 mission, 57 cataclysmic variables have been observed.



The light curves of each of these objects must be analysed to characterise their outburst frequencies and the shape of any possible super-outbursts. The student will be expected to analyse the light curves of these CVs, attempt to classify these systems, model the lightcurves and organise follow up observations if necessary.



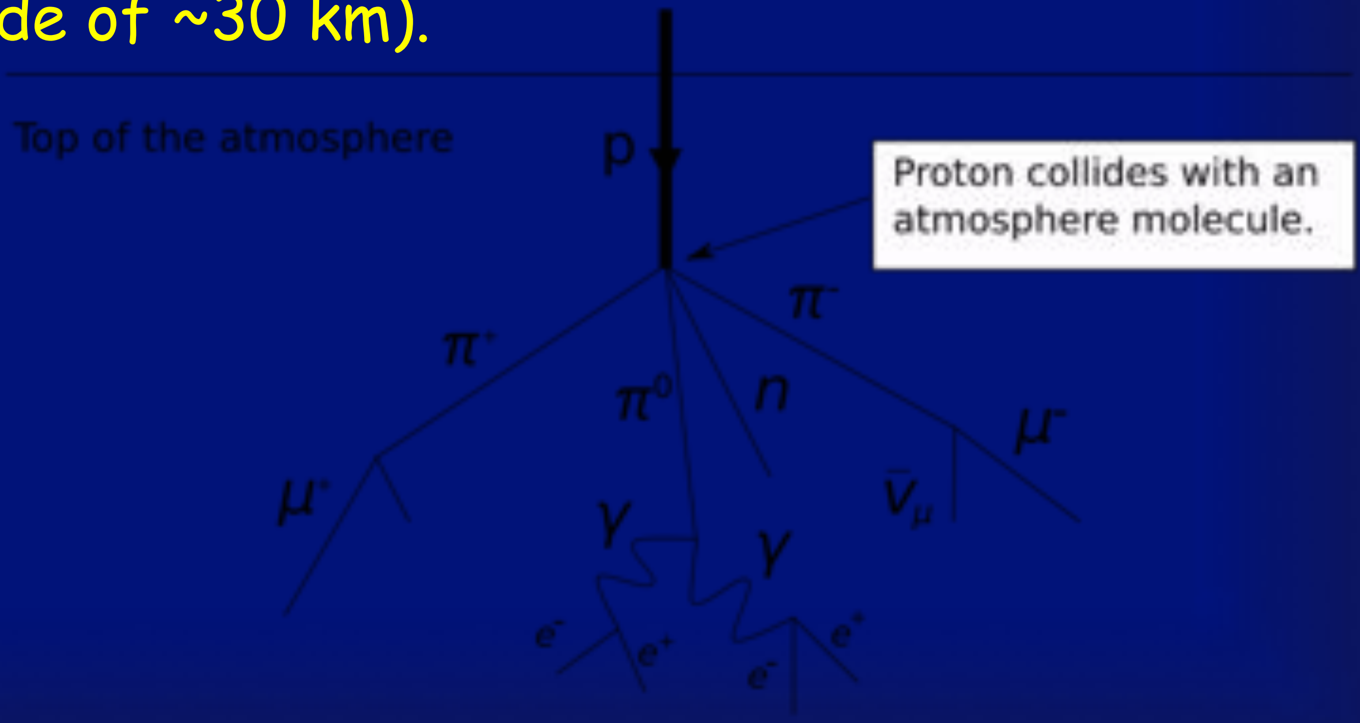

Cycles
100
200
300
400
500
600
6000
5000
4000
3000
2000
1000
Flux (e- s-1)
10
20
30
40
50
60
70
80
90
100
Days (BJD-2456206)
Flux
Days (BJD-2456206)
Flux
Cycles
Flux
Days (BJD-2456206)
Flux
Cycles


6×10^-15
4×10^-15
2×10^-15
4000
4500
5000
Wavelength (A)

Project 3

Development of a Muon detector [long]

Muons are generated when high energy Cosmic Rays (e.g. protons) interact with the upper atmosphere (at an attitude of ~30 km).



These muons (mass ~200 times that of an electron) move at relativistic speeds towards the ground where they can be detected. This gives us an estimate of the Cosmic Ray flux at the top of the Earths atmosphere. This in turn is related to the current solar activity.

This project takes its inspiration from a project carried out at MIT (https://arxiv.org/abs/1606.01196) to make a small desktop muon detector involving a scintillator and a silicon photomultiplier, in collabration with the Cork-based company Sensl (http://sensl.com/) and the Department of Electrical Engineering (UCC). This detector has been made, but not properly tested or calibrated.

Muon detector PCB and scintillator (left) and muon pulse (right)

The purpose of this project is to develop this experiment further, and correct the data non-astrophysical effects, enabling us monitor the long term effects of cosmic rays, and the solar wind, on the Earth atmosphere.

In addition, the student will be asked to modify the experiment so that it can be used to

(i) Measure the muon 2.2μs decay lifetime, and

(ii) Constrain the angle of incidence of the muons, ideally by combining the detector with a second.

For more details on any of these projects, please contact Paul Callanan via paulc@ucc.ie, or call by my office (104C).