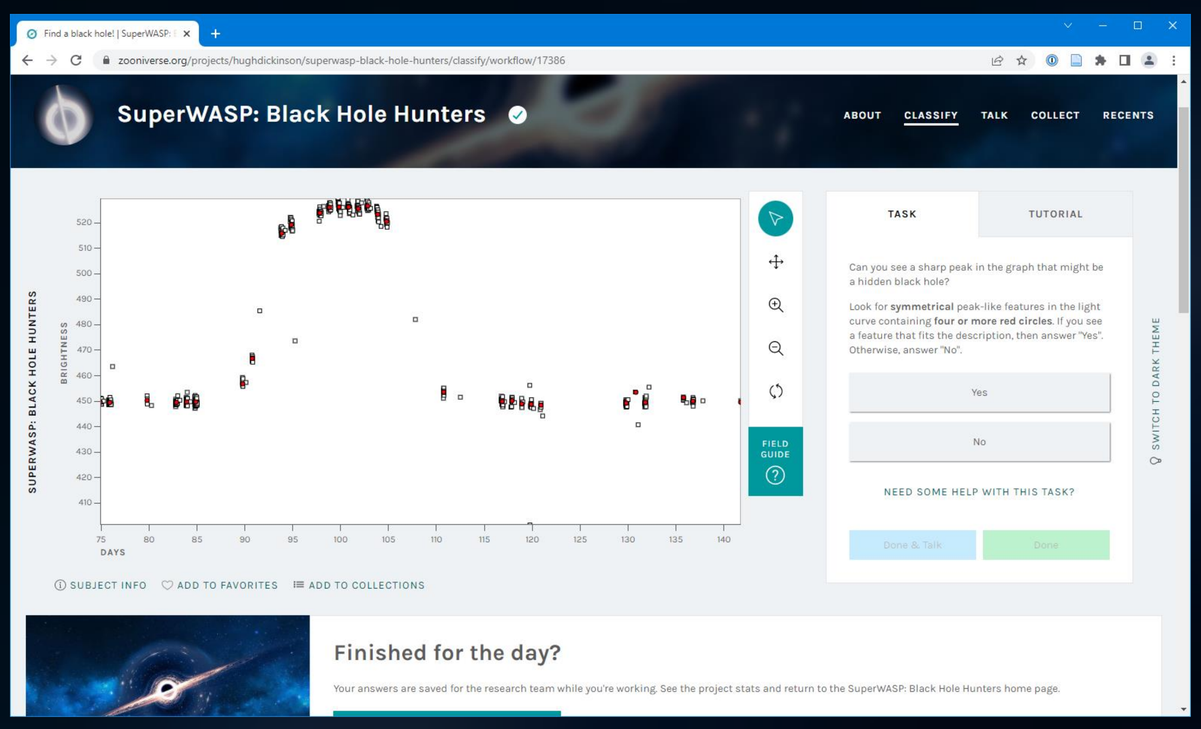
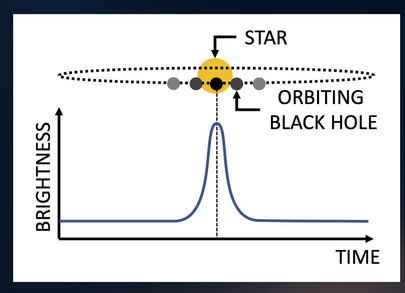
Black Hole Hunters

A citizen science search for black hole self-lensing



The Black Hole Hunters classification interface.

We're using **citizen science** to search for **black holes** in binary systems, by looking for the effect of **gravitational microlensing** on the companion star.



Brightness change due to lensing.

The aims of the project

We are searching the entire SuperWASP photometry archive (18 million lightcurves spanning over a decade) for microlensing events.

We hope to identify self-lensing events produced by binaries containing quiescent black holes.

This work will inform future searches using LSST and possibly allow us to constrain the population of quiescent black holes in binary systems.

The SuperWASP data

The SuperWASP survey took photometric measurements over a long baseline (12 years) and high cadence (up to more than nightly), covering the entire sky excluding the galactic plane. It could have observed a small number of microlensing events by chance.

The events we're looking for are very rare – we're looking for a few needles in a large haystack. Unfortunately the data are very noisy and there are a lot of false positives, rendering any automated search impossible. Therefore we are conducting a manual search of the archive instead, with the help of volunteers on the Zooniverse platform.

Volunteers give us their answers

They look at a binned light curve and tell us if they see a symmetrical peak in brightness.

They're instructed to ignore anything that lasts less than three days.

We combine the volunteers' answers

Each light curve is shown to nine different volunteers.

We take the consensus of the volunteers' votes.

We also take into account tags from the discussion forum.

We carry out vetting to remove false positives

We remove anything that can be explained by anything other than microlensing.

We compare to the nearest other SuperWASP targets to check for pipeline calibration errors.

We perform modelling to estimate black hole parameters

We fit both a self-lensing model and a chance alignment (point-source, point-lens) model with reasonable limits on black hole properties.

We try to judge which model is more likely.

The Zooniverse project

Light curve data have been binned in daily (red circles) and half-day (white squares) intervals. The volunteers are instructed to pay attention to the red circles and use the white squares to judge how noisy the data are. They are asked whether they see any symmetrical "peaks" in brightness which last longer than three days and stand out above the noise.

We collect answers on each light curve from nine volunteers, minimising the effects of mistakes and malicious users.

Data analysis

The Zooniverse volunteers can eliminate false positives due to noise, but there are other effects that mimic microlensing events (e.g. the full Moon). Where possible we can pre-filter these, but manual checking is required to identify effects we haven't anticipated.

Remaining events are then fitted against both a self-lensing model and point-source, point-lens model to derive the impact parameter and Einstein ring crossing time in each scenario. In cases where one set of parameters is implausible we can favour one model over the other. We hope to publish initial results in late 2022 or early 2023.

Adam McMaster[1], Andrew Norton[1], Hugh Dickinson[1], Matthew Middleton[2], Ulrich Kolb[1]

[1] School of Physical Sciences, The Open University
[2] University of Southampton

Get in touch or say "hi" if you see me!

adam.mcmaster@open.ac.uk

@BlackHoleHunter

@AstroAdamMc

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