Black Holes in Binary Star Systems

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What are black holes?

A black hole is an extremely dense object with a huge gravitational pull. It is made when a star, at least 10 times the mass of our Sun , finishes burning all of its fuel and the huge gravitational attraction then causes the massive star to collapse to just a few km in radius as defined by the event horizon.

What are binary stars?

Most stars are found in groups that are gravitationally bound systems. The majority of these are binary systems in which two stars orbit each other around a common centre of mass. Binary systems are very important in astrophysics because they allow us to work out various Stellar parameters such as the mass and spin of black holes.

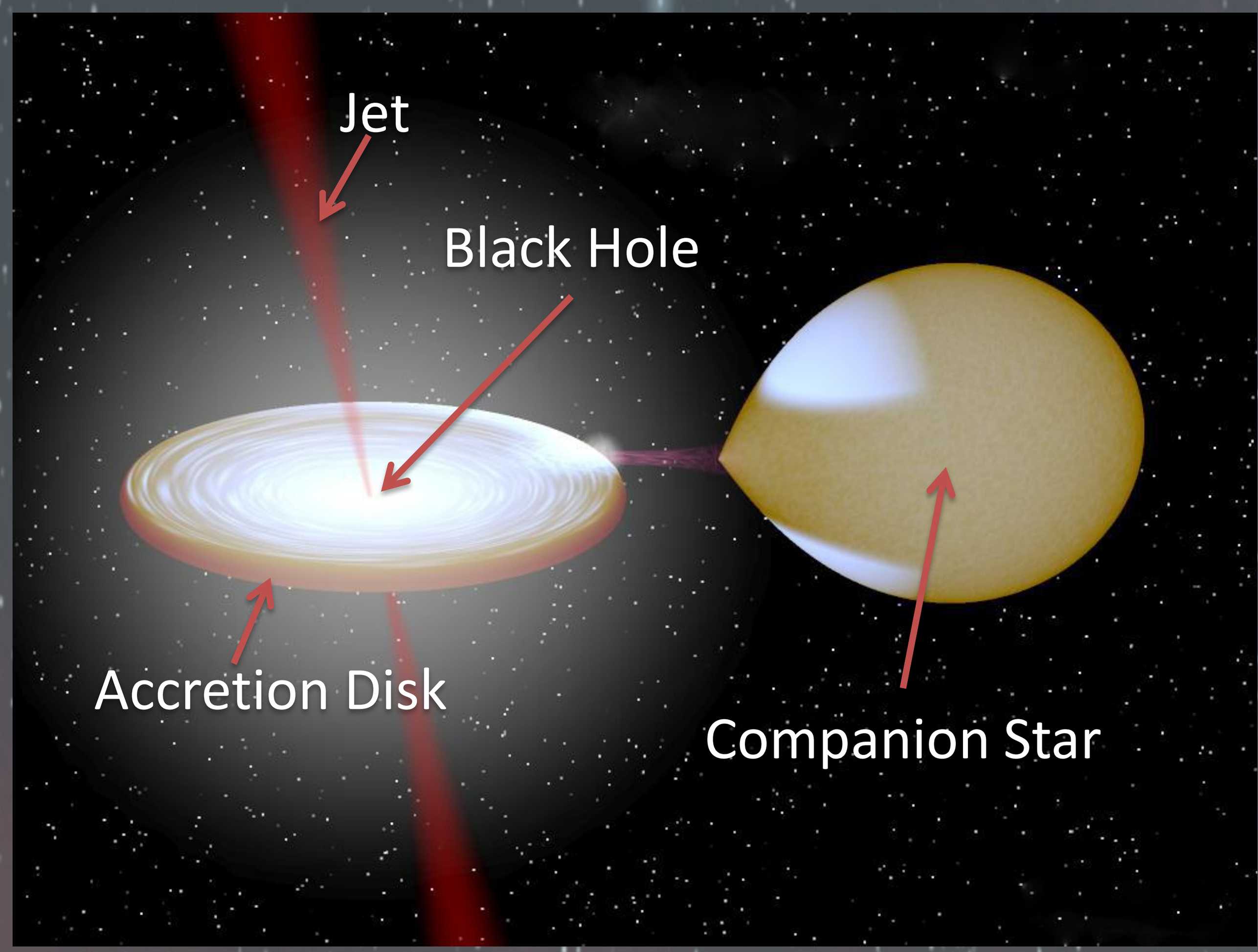

Fig. 1. An example of a X-ray binary system.

Why do we use X-rays?

X-rays are a form of light but much more energetic than visible light. Because of the X-rays penetrating power they are very useful in astronomy. We use them to probe deep into the universe. X-rays are emitted from very hot sources, typically millions of degrees. such as the hot an luminous gas in the fast moving accretion disk surrounding the black hole. Fortunately for us, X-rays are absorbed by the Earths atmosphere. This means if we want to observe them we must do so from space. The first X-ray observations were from balloons. Later, rockets were introduced and now we use satellites. Data from the RXTE satellite was used throughout this research.

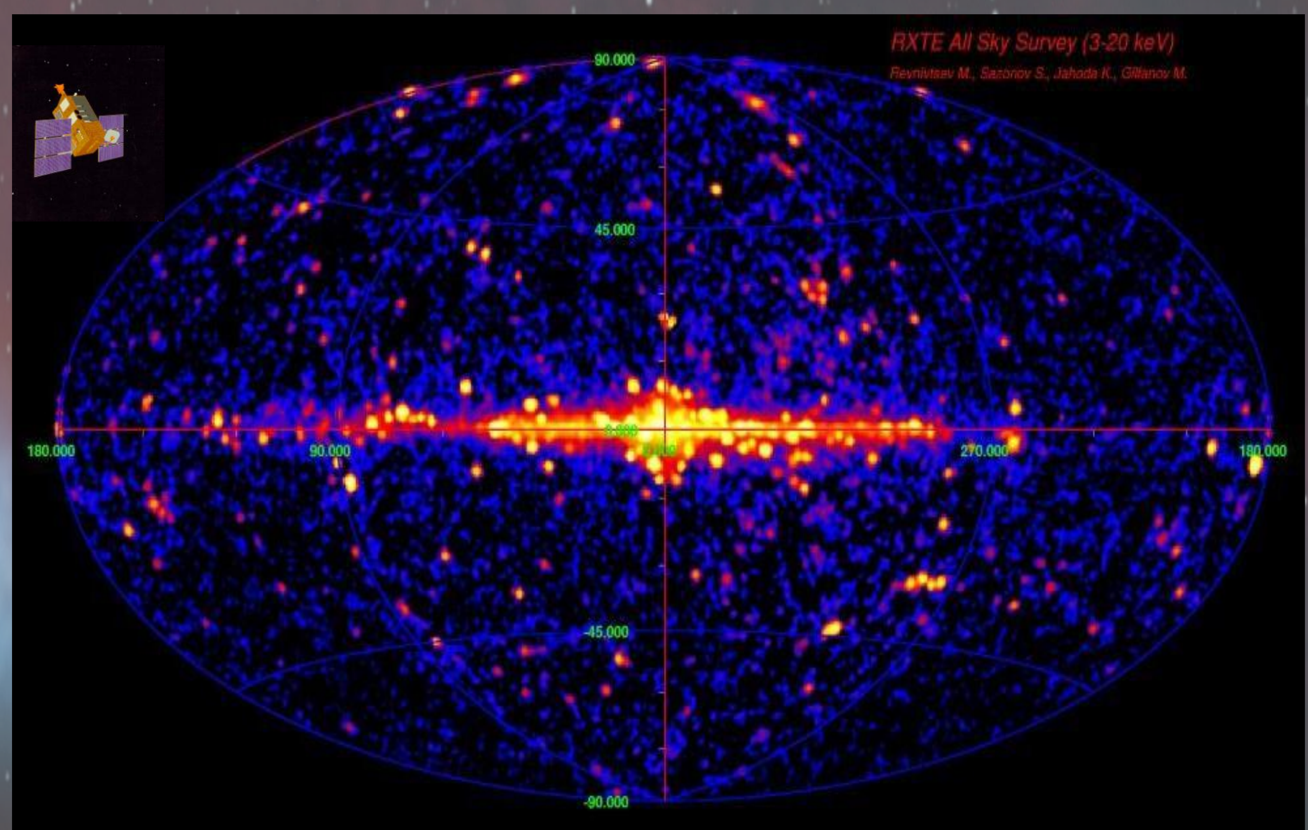

Fig. 2. A view of the sky in X-rays from the RXTE All-Sky monitor.

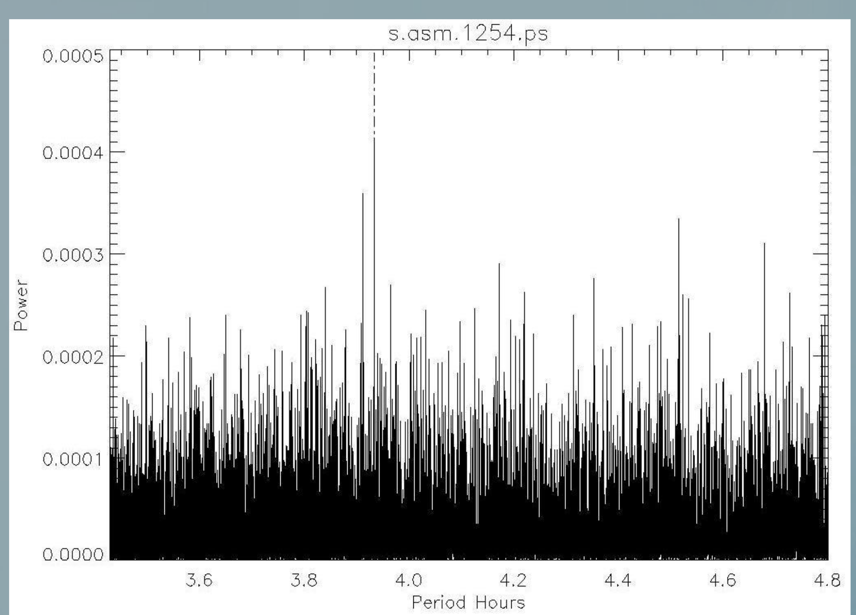

Fig. 3. Whitened, fast Fourier transform of ASM data for X1254-690.

Aims:

Firstly, we must find the period of the companion star around the source 4U 1957 +11. The ~13 year light curve obtained from the ASM can then be folded on this period. The mass and spin can be calculated from analysis of the folded light curve. Finally, we are able to deduce whether or not 4U 1957+11 is a black hole or neutron star based upon the values of mass and spin.

Method:

We request X-ray light curves from the ASM and PCA of the RXTE satellite. We use various filtering techniques to enhance likely periodicities. We then fast Fourier transform the light curves to produce two periodograms., Fig. 3 & Fig. 4. The two periodograms are combined to reveal the period of the companion star.

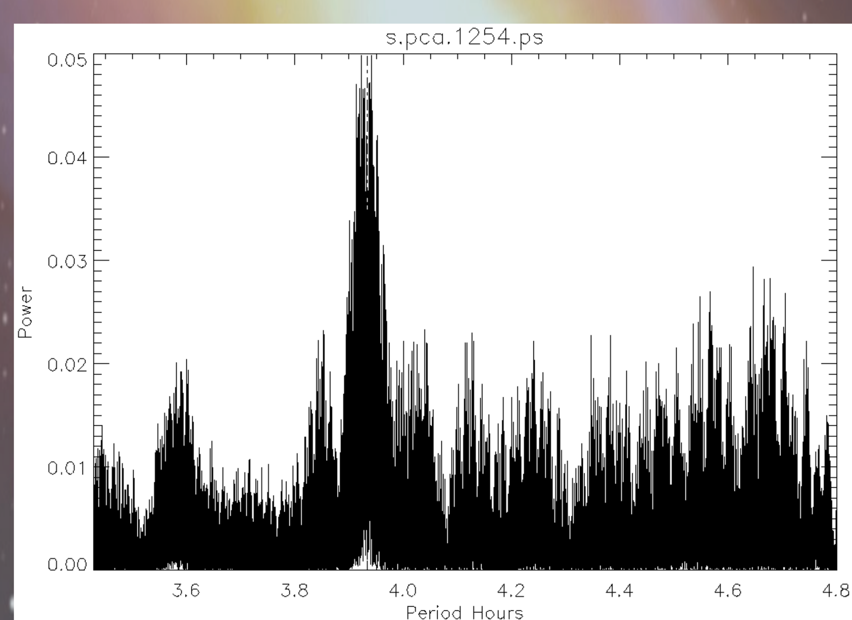

Fig. 4. Whitened, fast Fourier transform of PCA data for X1254-690.

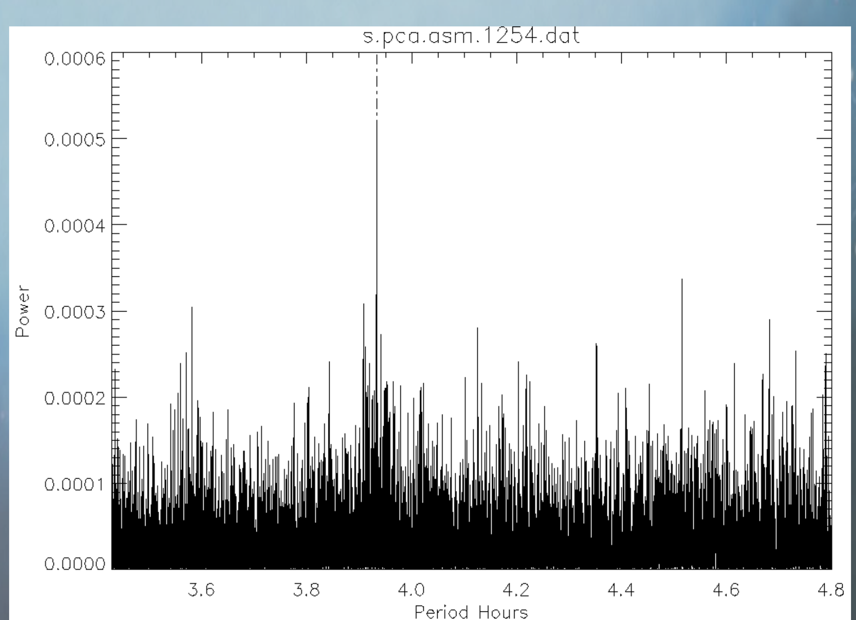

Fig. 5. Combined PCA and ASM data.

Outcomes:

We have successfully confirmed the periods of 4 black holes and neutron stars! We are yet to confirm the period of 4U 1957+11, and hence, we have not calculated the mass and spin but I am continuing to work closely with my tutor and supervisor at Harvard so that we can achieve our original aims. I am also currently searching for completely unknown periods of some more famous sources. The research is very much in its infant stages but looks promising!

If you would like to find out more then please email me, J.M.C.Fenton@Warwick.ac.uk. Special thanks to everyone involved with the Undergraduate Research Scholar scheme, staff at the Harvard-Smithsonian Centre for Astrophysics and my tutor Danny Steeghs.

Background : Artistic impression of Cygnus X-1. On the left is the bright blue supergiant star HDE 226868 (30 times the mass of our Sun). Credit: ESA & Hubble.