First Science with SALT: Observations of eclipsing polar

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The *Southern African Large Telescope (SALT)*, inaugurated in November 2005, is today releasing its first public research results, giving new insight into an exotic pair of stars closely orbiting one another.

Figure 1. The artist Bob Watson's painting o 'Polar' binary.

This research uses a strength of the SALT design which is rare among large telescopes, the ability to take 'snapshots' of stars in very quick succession, so that we can study the rapidly changing properties of compact stars, especially as they pull in gas from their companions or surroundings.

The gravitational field of a compact star commonly pulls in gas from a companion star -- the radiation (especially X-ray) emitted as this happens is one of the indirect ways we use to detect black holes. It's also the way that mass builds up on some compact stars until supernova explosions blow them apart, giving us the 'Type Ia' supernovae recently used to show that the expansion of the universe is speeding up.

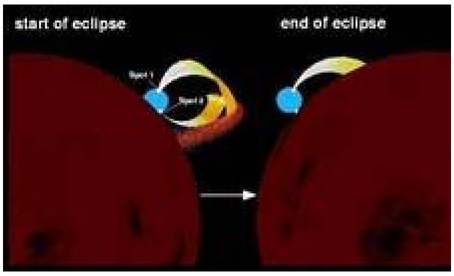

Figure 2. Earth Observer's view of a polar at the start (left) and end (right) of eclipse.

The new SALT results are for a 'polar' binary star system, which contains a compact star called a 'white dwarf' – a star which has used up its original store of nuclear energy, then shrunk to about one millionth of the volume of a star like our sun. In a polar this 'white dwarf' also has a very strong magnetic field, which strongly influences how the hot gases from its relatively ordinary companion reach the white dwarf surface.

Polars are the most readily accessible objects we know for studying gas accretion in strong magnetic fields, and are among the closest orbiting pairs of stars we know: both stars and their orbits would fit inside the Sun!

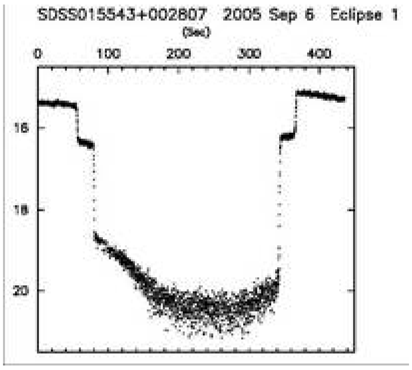

Figure 3. Sequence of brightness measurements of the polar. Each point is a 112 millisecond exposure.

The polar which SALT has studied takes only one and a half hours to complete an orbit (compared to a month for the earth and moon, and a year for the earth and sun). Despite being a pair of stars, they are so close you would see them as only one star in a telescope. One of the stars is an ordinary star like the Sun, but cooler, redder and about 1/3 of the Sun's mass and radius. Its 'white dwarf' companion is hundreds of thousands of times as dense as the Earth -- a chunk of white dwarf as large as a pair of dice would weigh as much as two small trucks. This gives the white dwarf an intense gravitational field that sucks in material from the larger star. But it is the white dwarf's huge magnetic field (30 million times as strong as the Earth's) that forces the gas from the cool star to impact at the white dwarf's magnetic poles. Figure 1 is an artist's impression of what such a typical such binary system might look like: the cool, red star is in the background with the stream of gas being sucked off by gravity shown in white, finding its way down to the white dwarf along a path shaped by magnetic forces.

Imagine now that you are looking at a binary system like this from "behind" the cool, red star with your viewing angle such that the red star, once an orbit, passes in front of the white dwarf and cuts off your view of it. If you had a telescope like SALT, and a camera on it like SALTICAM, which can make brightness measurements every 100 milliseconds, you would see the brightness of the system dim quite drastically because the light from the gas crashing on to the magnetic poles of the white dwarf completely outshines the light from everything else.

Figure 2 shows a cartoon of your view of the system at the start of eclipse (left) when the red star is just about to block our view of one magnetic pole, labeled Spot 2, and at the end of eclipse (right) when the red star has just uncovered Spot 2.

Figure 3 is a sequence of brightness measurements and the evidence for what has just been described can be seen in the sequence. you look closely at Figure 3, you will see it has a first sudden brightness drop (Spot 2 disappearing), followed about 25 seconds later by a second sudden brightness drop (Spot 1 disappearing). Towards the end of the sequence there are sudden rises in brightness corresponding to the earlier sudden drops as the spots are uncovered. The gas stream between the stars also gives some light, and this accounts for the rounded shape of the bottom of the eclipse.

This sequence of measurements is better than anything that has been obtained before, and SALT's advantages over all other large telescopes for this type of research should allow SALT astronomers to lead in probing the mysteries of these 'cannibal stars'.

Full scientific details are in the first scientific paper (or report) from SALT, which has been accepted for publication in the peer-reviewed journal Monthly Notices of the Royal Astronomical Society. An electronic preprint of the article is available online at xxx.lanl.gov/archive/astro-ph, entry number 0607266.

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