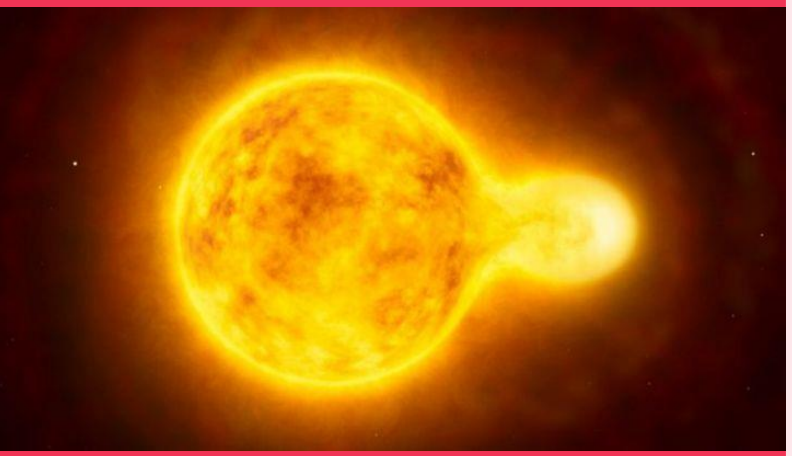
#RASposter2020

Red novae candidates: An investigation of long-period near-contact giant eclipsing binaries

We have identified 27 unusually long period red giant near-contact eclipsing binary stars.



Artist's impression of a contact binary [Science Photo Library]

Heidi B. Thiemann

Supervisors: Andrew J. Norton, Ulrich C. Kolb

School of Physical Sciences, The Open University

heidi.thiemann@open.ac.uk

@heidi_teaman

Background

What is a contact binary star?

A contact binary star is a system with two close stellar components. The stars orbit so closely that they have started to merge and share a gaseous envelope. Contact binary stars typically have a short orbital period of less than one day (Fig 1).

We have identified a set of candidate stars that appear to be long-period examples of near-contact eclipsing binaries, with orbital periods of up to a month or more.

To be in contact, or near contact, at such long periods requires both stars in the binary to be giants. This is a new and unusual configuration of binary stars.

Why is this exciting?

Contact binary star mergers are thought to be the progenitors of red novae, but none have been identified pre-nova. Only one progenitor of such an event has ever been studied, V1309 Sco, and that was only recognised retrospectively, after the merger occurred. The eruption of V838 Mon (Fig 2) is now thought to have been a red nova.

Red novae are essentially the smaller, redder, dustier, and more mysterious cousins of supernovae. There are only ~16 known red novae.

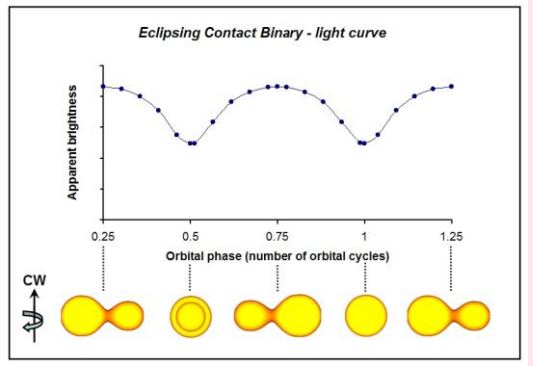


Fig 1. Light curve of a contact binary [Cronodon]

Fig 2. The light echo of the 2002 eruption of V838 Mon, now thought to be a red nova. [NASA/ESA]

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We spent two years monitoring 27 candidate binary stars using telescopes from around the world.

COAST, sister telescope to PIRATE [OU]

Heidi B. Thiemann
Supervisors: Andrew J. Norton, Ulrich C. Kolb
School of Physical Sciences, The Open University
heidi.thiemann@open.ac.uk
@heidi_teaman

Methods

1. We **identified 27 candidate binaries** from a search of the *SuperWASP Periodicity Catalogue (Fig 3),* the *ASAS-SN Catalogue of Variable Stars,* and through our Zooniverse citizen science project, *SuperWASP Variable Stars*.

2. We **conducted a 2-year long follow-up campaign** of multi-colour photometry of the 27 targets using the LCO robotic telescopes and The Open University's PIRATE observatory. We have taken spectroscopy of northern targets with the Liverpool Telescope, and southern targets using the 74-inch (Fig 4) and SALT, both based in South Africa.

3. We **used observational data for modelling.** Using the multi-colour photometry with radial velocities from spectroscopy, we have been able to model the parameters of the stellar components using the Wilson-Devinney code, implemented in the PHOEBE binary star modelling package.

4. We **are currently modelling the evolution** of the binaries using MESA and binary_c to understand whether they could form red novae.

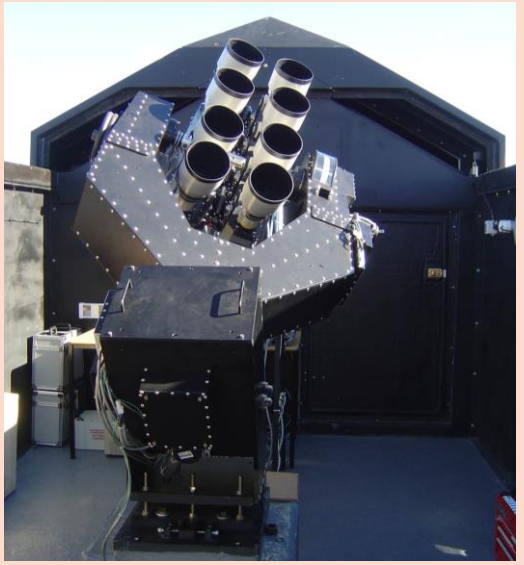

Fig 3. SuperWASP-South [SuperWASP Consortium]

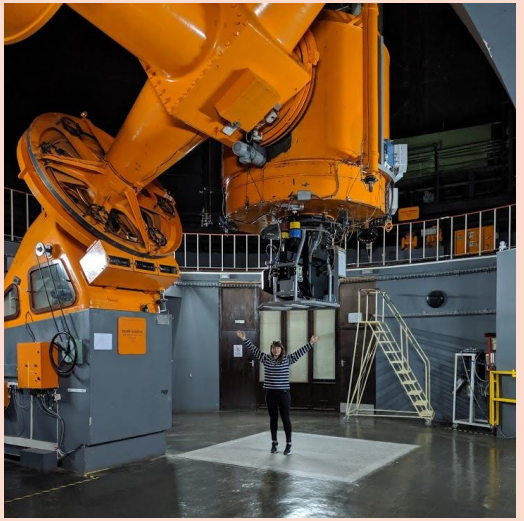

Fig 4. At the 74-inch telescope [Thiemann]

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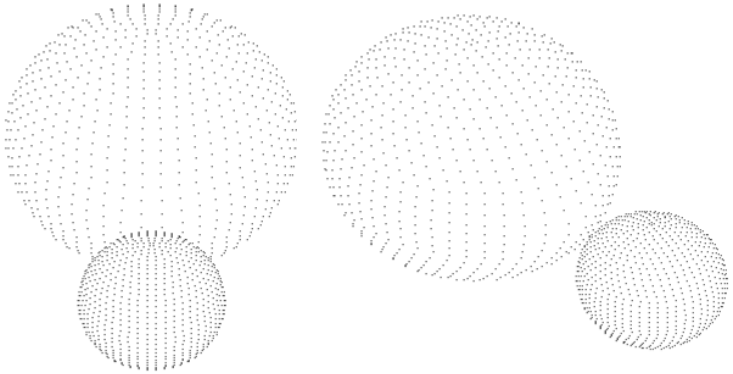
Red novae candidates: An investigation of long-period near-contact giant eclipsing binaries

We have confirmed that 12 out of 27 candidates are real near-contact red giant eclipsing binary stars.



PHOEBE model of a near contact binary [Thiemann]

Heidi B. Thiemann

Supervisors: Andrew J. Norton, Ulrich C. Kolb

School of Physical Sciences, The Open University

heidi.thiemann@open.ac.uk

@heidi_teaman

Results

How did we model the stars?

Using PHOEBE, a binary star modelling programme, we have modelled the stellar components of the targets.

Fig 5 shows the SuperWASP phase folded light curve of one of our binaries. Fig 6 shows the corresponding radial velocity plot. Fig 7 shows the resulting PHOEBE model of the binary system.

For this system, each star has a mass of ~3M_{Sun}, and a radius of ~19-26R_{Sun}.

What do the results show?

We have shown that 12 out of 27 candidate binary stars are real near-contact red giant eclipsing binaries. The other 19 are likely to be Cepheids.

9 binaries are semi-detached systems, where one star fills or overflows its Roche lobe. 3 are W UMa type systems, surrounded by a common envelope.

These binaries are all made up of late-type giants (G to K), with low temperatures (3500-6000K), relatively low separations (13-70R_{Sun}) and low masses (0.5-5M_{Sun}).

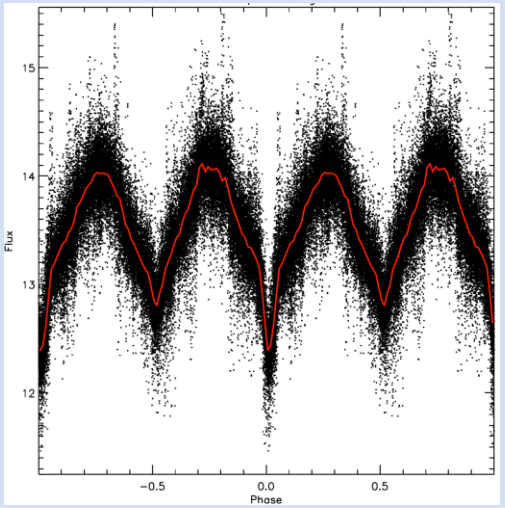


Fig 5. Light curve of a binary [Thiemann]

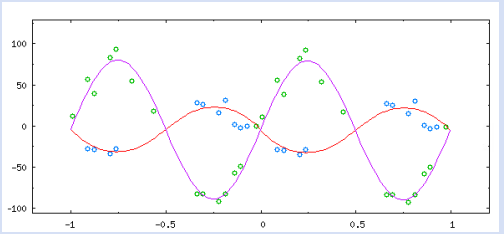


Fig 6. Radial velocity plot of a binary [Thiemann]

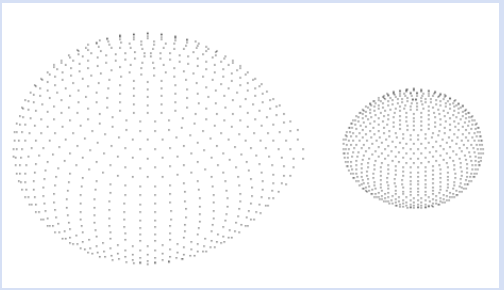


Fig 7. PHOEBE model of a binary [Thiemann]

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This discovery gives us an unrivalled opportunity to identify binary star mergers before they happen.

The expanding light echo of V838 Mon [NASA/ESA]

Heidi B. Thiemann
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School of Physical Sciences, The Open University
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Ongoing and future work

We want to answer the questions:

- What is the lifecycle of a near-contact red giant eclipsing binary?
- On what timescales will a merger happen?
- Will the binaries definitely form red novae?

How will we do that?

We are currently modelling the evolution of these binary systems using MESA and binary_c, 1D stellar evolution codes. This will help us understand the astrophysical processes that will occur (Fig 8).

By studying these binaries, we have an opportunity to identify and characterise binary mergers before the merger event itself, and advance our understanding of the formation of red novae.

Get involved

You can identify your own binary stars and help us to build up a better idea of what stars are in the night sky. To join in, visit the *SuperWASP Variable Stars* Zooniverse project (Fig 9): bit.ly/3fOJEqc

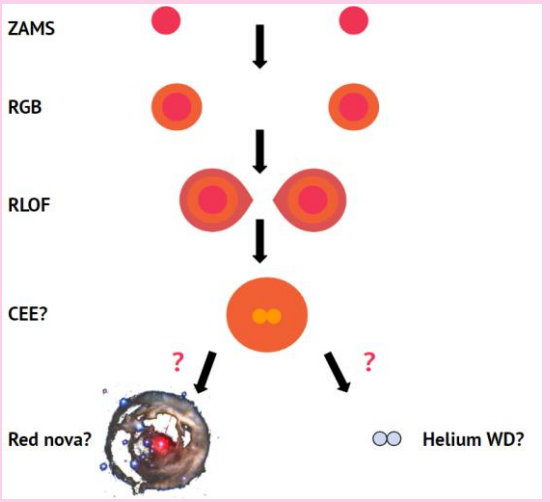

Fig 8. Possible evolutionary pathways of the binary stars [Thiemann]

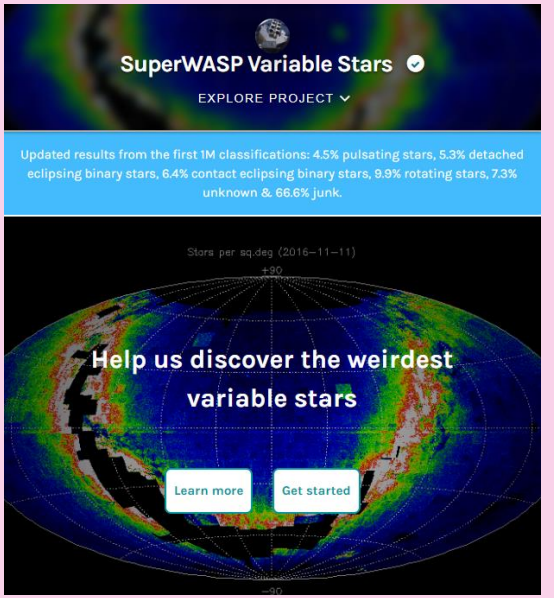

Fig 9. Zooniverse project [Norton/Thiemann]

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