Galactic archaeology

Are there any 10 billion year old accreting binary stars?

David Brown Supervisors: Tom Marsh; Boris Gaensicke

Introduction

Cataclysmic variables (CVs) are a type of binary star, consisting of a white dwarf pulling material from the surface of its companion star, usually a star similar to the sun (figure 1). They are distinguished by their variable brightness, and by occasional outbursts during which the disc of accreting material rapidly increases in temperature and density, temporarily increasing the brightness of the binary. My aim was to determine whether any of the 254 CVs discovered so far belong to the Galactic halo.

The Milky Way is a spiral galaxy consisting of a central bulge with surrounding disc of spiral arms and a spherical halo. Old stars, formed during the early stages of the Galaxy's existence, have very elliptical orbits and therefore tend to be found in the halo. Young stars, formed comparatively recently in Galactic history, tend to have much more circular orbits, and are therefore more likely to be found in the disc. If we can find out where in the galaxy a star resides, we can therefore say something about its age.

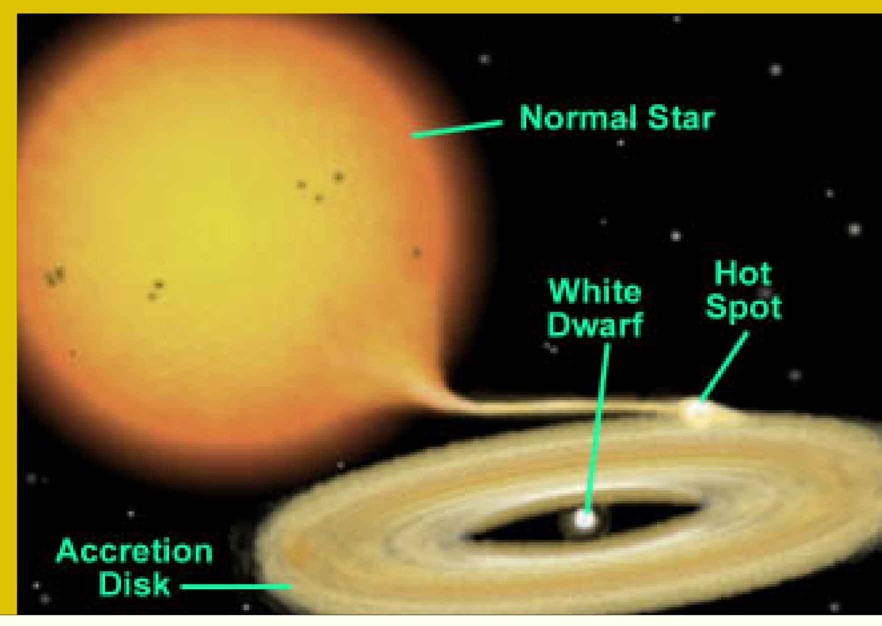

Figure 1: An artist's impression of a CV, showing the white dwarf and its companion star. Also shown are the stream of material being pulled from the surface of the companion by the white dwarf, and the disc that this material forms.

Figure 2: An image of the Milky Way taken by the Cobe satellite, showing the central bulge and disc. The halo surrounds all of this, but is less densely populated.

Motion

The motion of stars through space can be split into two parts: motion along our line of sight (radial motion), and visible motion across the sky (proper motion).

To calculate the proper motions I compared an image of each CV from the 1940s/1950s with an image from the 1980s/1990s. Identifying the CV in the two images allowed me to calculate its position when each of the images was taken, which in turn led to a value for the proper motion of the CV

For the radial motion I was able to calculate the speed along our line of sight. I analysed the spectrum of each CV using a computer program to find the Doppler shift of the spectrum, which allowed calculation of the radial velocity.

Knowing the radial velocity of an object is only helpful if you also know its distance from us, but calculating the distance to CVs is difficult owing to their variability. There are many subclasses of CV, each with different properties, so astronomers are unable to find a generic distance calculation method. I used a variety of methods from the literature, based on different methods of estimating the brightness of the CV.

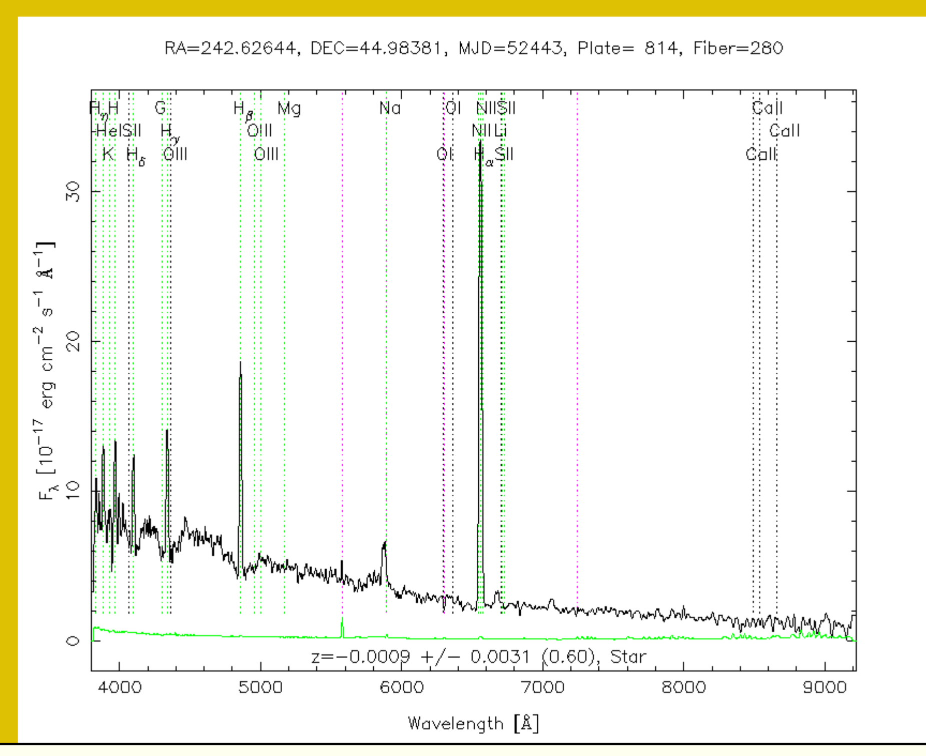

Figure 2: An example CV spectrum. The large peaks are the spectral lines, from which I was able to calculate the radial velocity using the Doppler shift.

Galactic position

To find the position of an object within the Galaxy, its velocity relative to the Sun must be calculated. This is split into U (motion towards or away from the centre of the Galaxy), V (motion in the direction of Galactic rotation) and W (motion at right angles to the disc). Using a conversion method from the literature, I calculated these velocities and plotted U against V.

The U and V velocities, when plotted, give an indication of which component of the galaxy an object belongs to. Disc stars tend to cluster around (0,0) as they move at roughly the same speed as the Sun, but halo stars have much greater speeds in the direction of rotation and so lie off to one side.

It is also possible to use the values of U, V and W to plot the orbit of an object through the Galaxy, which gives the eccentricity. The more circular an orbit the lower its eccentricity. Plotting the angular momentum of an object against the eccentricity of its orbit separates halo stars, which tend to lie to the right, from disc stars which tend to lie to the left.

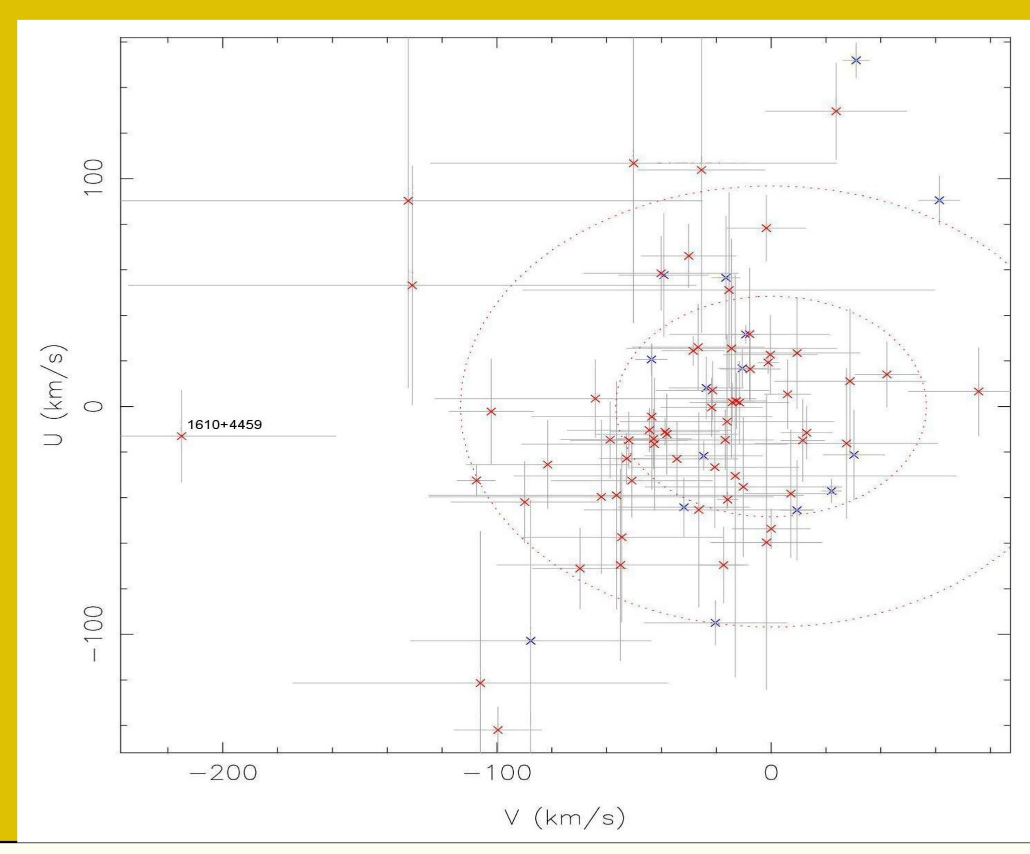

Figure 3: A plot of the U and V velocity components for all of the CVs included in my final analysis. Clearly visible are the clump around (0,0) representing objects moving in the disc, and SDSS1610+4459, the outlying halo object.

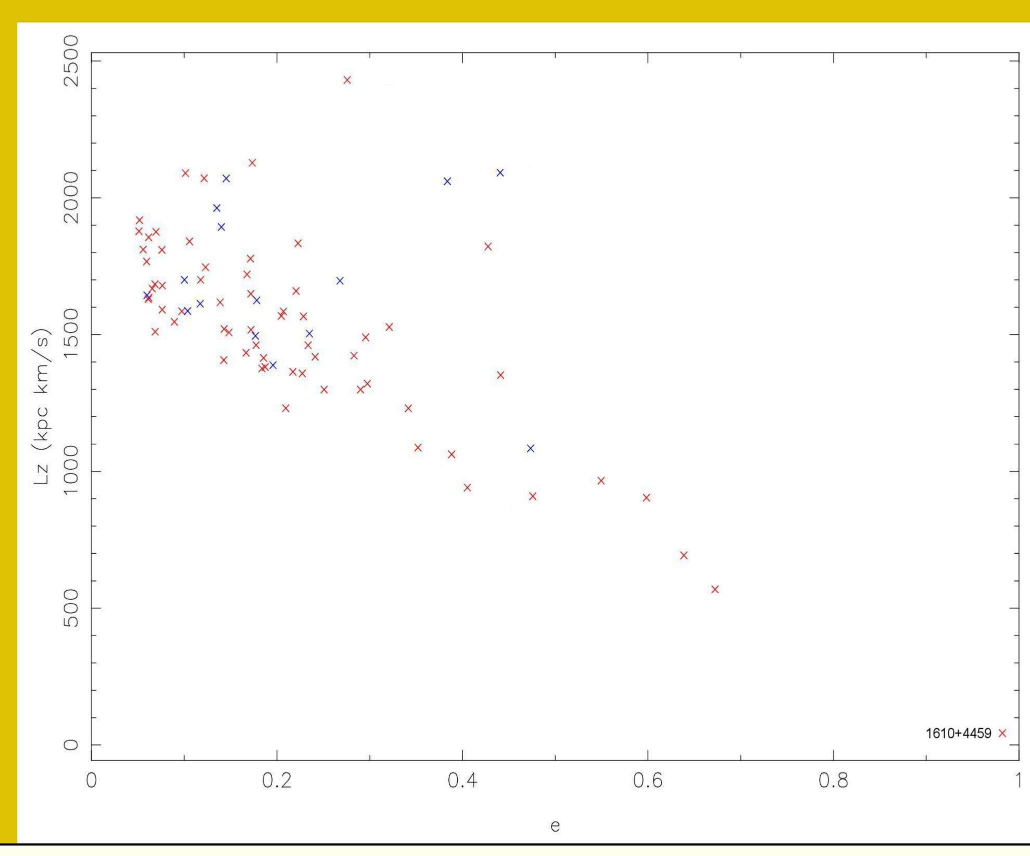

Figure 4: A plot of angular momentum against eccentricity for all of the CVs included in my final analysis. SDSS1610+4459 is clearly separated from the rest of the CVs, confirming its status as a halo star.

Results

From my results, I have identified one clear candidate for membership of the Galactic halo, SDSS1610+4459. It is clearly visible as an outlying point in figures 3 and 4. Several other CVs appear to be possible candidates, and warrant further investigation.

I would like to thank Tom Marsh and Boris Gaensicke for their help throughout this project, which was funded by the Centre for Learning Development as part of the Undergraduate Research Scholarship Scheme.

THE UNIVERSITY OF WARWICK

d.j.a.brown@warwick.ac.uk
tom.marsh@warwick.ac.uk
boris.gaensicke@warwick.ac.uk

URSS