Gaseous debris discs around white dwarfs

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Artists impression of SDSS J1228+1040 by Mark Garlick. Image of Saturn from NASA's Cassini mission, NASA image saturn_malmerCassini_5m.jpg
Talk Outline

• **One** - The gaseous debris disc around SDSS J1228+1040

• **Few** - Common variability of gaseous debris discs

• **Many** - Frequency of gaseous debris discs around white dwarfs
Remnant Planetary Systems

SDSS J1228+1040

Jura & Young, 2014, Annu. Rev. Earth Planet. Sci., 42, 45

Remnant Planetary Systems

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The gaseous component of the debris disc

SDSS J1228+1040

Gänsicke et. al. 2006, Science, 314, 1908
Accretion disc in a binary

K. Horne and T. Marsh
Accretion disc in a binary

K. Horne and T. Marsh
The gaseous component of the debris disc

Gänsicke et. al. 2006, Science, 314, 1908
10 out of 18
Doppler Tomography

The extent to which this is not the case is one measure of violations of the basic assumptions made.

Fig. 3. A model image and the equivalent profiles formed by projection normal to the line shown at orbital phases 0.25 (right-most profile) and 0.5 (lower profile).

Fig. 3 shows a pictorial representation of this process for two projection angles. The artificial image has been created with a spot which can be seen to project into different parts of the profile at different phases. Tracing back from the peaks along the projection directions leads to the position of the original spot. This is in essence how line profile information can be used to reconstruct an image of the system.

As a series of line profiles at different orbital phases is therefore nothing more than a set of projections of the image at different angles. The inversion of projections to reconstruct the image is known as "tomography", the case of medical X-ray imaging being perhaps the most famous, although it occurs in many other fields too. I now look at the two methods that have been applied in the case of Doppler tomography.

3.2 Inversion Methods

The mathematics of the inversion of projections dates back to the work of Radon in 1917 [60]. If one knows the function (in my notation) f(V, \phi) for all V and \phi, an artificial transformation—the Radon transform—can produce the desired end product, I(Vx, Vy). In reality, things are not so easy, and we never have the luxury of knowing the line profiles at all orbital phases, although one can get close in some cases. With the advent of fast computers and the development of medical imaging, interest in the implementation of Radon's transform...
Doppler Tomography

Doppler Tomography

Doppler Tomography


2011-01
Doppler Tomography

Time evolution of peaks

Doppler Tomography

2011-01

Sharp feature
Red extension

Wavelength [˚A]
Doppler Tomography

New observations in March and May

2003-03
2007-07
2011-01
2014-03
2015-05

Normalised Flux

Wavelength [Å]

Normalized Flux

Wavelength [Å]

2016 March

2016 May
A Whole New Map

Manser et. al. in prep.
Some more comparing

Manser et. al. in prep.

New (20 epochs)

Old (18 epochs)
Spiral?
Even newer data!

2016 May

2017 March 01

Wavelength [Å]

Normalised Flux

8450 8500 8550 8600 8650 8700
Reached half way?

![Graph showing normalised flux vs velocity for 2006 Flipped and 2017. The graph indicates a peak at around -400 km/s and another peak at around 400 km/s for both years. Normalised flux values range from 0.5 to 3.5.](image)
Coadded X-Shooter spectrum
April 2010 Hubble Spectrum

March 2016 Hubble Spectrum

Normalised Flux

Wavelength [Å]

Manser et. al. in prep.
Comparing the two...

Normalised Flux vs. Wavelength [Å]

Manser et al. in prep.
Circumstellar gas

Normalised Flux

Wavelength [Å]

Si IV

Manser et. al. in prep.
Circumstellar gas

![Graph and Image](image_url)

**Normalised Flux**

- Wavelength: \(\text{˚A}\)
- **Si IV**: -750 to 750 km s\(^{-1}\)

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Manser et al. in prep.
Other variable gas discs

SDSS J1228+1040

Morphologically variable

SDSS J0845+2257  SDSS J1228+1040

Morphologically variable

SDSS J0845+2257  SDSS J1228+1040  SDSS J1043+0855

Variable strength

SDSS J1617+1620

Variable strength

SDSS J1617+1620

SDSS J1228+1040


Variability

e - Gaseous emission

a - Gaseous absorption

v - Spectroscopic or photometric Variability

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<tr>
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Detected Remnant Planetary System statistics

Metal pollution  Koester et. al. 2014  25 - 50 %
Detected Remnant Planetary System statistics

Metal pollution  Koester et al. 2014  25 - 50 %

Dusty disc  Farihi et al. 2009  Rocchetto et al. 2015  1 - 3 %
Detected Remnant Planetary System statistics

Metal pollution  Koester et. al. 2014  25 - 50 %

Dusty disc  Farihi et al. 2009  Rocchetto et al. 2015  1 - 3 %

Gaseous component  ??? %
The sample

Figure 2. Colour–colour diagrams illustrating the location of the 27 639 DR7 spectroscopic objects that we used as training sample for our selection method. DA white dwarfs, non-DA white dwarfs, NLHS and quasars are shown as blue, yellow, red and green dots, respectively. The colour cuts that define our initial broad selection from Table 2 are overlaid as red lines. Objects outside this selection were not classified and are therefore plotted as grey dots.

The sample
The frequency of gaseous discs

9079 single white dwarfs
The frequency of gaseous discs

9079 single white dwarfs

6 Gaseous components
The frequency of gaseous discs

9079 single white dwarfs

6 Gaseous components

Frequency of observable gaseous debris discs at white dwarfs

$0.07^{+0.03}_{-0.02}$ %
Detected Remnant Planetary System statistics

Metal pollution  Koester et. al. 2014  25 - 50 %

Dusty disc  Farihi et al. 2009  Rocchetto et al. 2015  1 - 3 %

Gaseous component  0.07 %
Detected Remnant Planetary System statistics

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<td>Debris discs with a gaseous component</td>
<td>2 - 10 %</td>
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Summary

• SDSS J1228+1040 is well studied, but still many unanswered questions.

• An observable gaseous component appears to be linked with variability

• Determined the frequency of a gaseous component to a debris disc at a white dwarf.
Summary

- SDSS J1228+1040 is well studied, but still many unanswered questions.
- An observable gaseous component appears to be linked with variability
- Determined the frequency of a gaseous component to a debris disc at a white dwarf.

Thanks for listening!

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