The grating spectra of the SSS classical novae V5116 Sgr and V5115 Sgr

Glòria Sala  (UPC-IEEC, Barcelona)
Margarita Hernanz (CSIC-IEEC, Barcelona)
Jan-Uwe Ness (ESAC-ESA)
**V5116 Sgr = Nova Sgr 2005b**

Discovered on 2005 July 4.049 (Liller 2005, IAUC#8559), with $V \sim 8$

Reached maximum on July 5.085, $V \sim 7.2$

**DISTANCE DETERMINATION:**

We need:
1. time to decrease 2 mag, ($t_2 = 6.5 \pm 1$ day) and
2. observed magnitude at maximum.

Both quite well determined in V5116 Sgr thanks to pre-maximum detection

Using Della Valle & Livio (1995) $M_V - t_2$ relation, the observed $t_2$ indicates $M_V = -8.8 \pm 0.4$. With the observed colour ($B-V = +0.48$, Gilmore & Kilmartin 2005) this implies a distance of $11 \pm 3$ kpc. (consistent with Ederoclite & Mason 2006, RS Oph meeting)
* Optical $\Rightarrow$ orbital period of $2.9712^{+/-0.0024}$ hr.

** high-inclination ** system with ** irradiation ** effect on the secondary star.


* OM data of our two XMM observations, in 2007 and in 2009 support this hypothesis: bright optical source when SSS on (2007), faint when SSS off (2009).

*Fig. 2.* A selection of our observations (4 detrended best runs; 1, 2, 11, and 13). The solid curve is the sinusoidal fit (plus first harmonic) to the data using the period derived in this paper.

V5116 Sgr: amazing X-ray light-curve

EPIC spectrum with same temperature in “low” and “high”

Only luminosity is changing by a factor 8!

During high flux,
$L=3.9(+/−0.8)×10^{37} \text{ erg/s}$ (for $d=10\text{kpc}$)
imply $R=6×10^8 \text{ cm}$, compatible with whole

OBSCURATION OF THE CENTRAL WD DURING 2/3 OF ORBIT

BY IRREGULAR, ASYMMETRIC ACCRETION DISC?

OR THICK RIM OF ACCRETION DISC?

IN HIGH INCLINATION SYSTEM
V5116 Sgr: RGS spectra

Period: 2.97h
V5116 Sgr: RGS spectra
HIGH

Soft continuum with absorption lines
- at rest wavelength
- N and O, but no C
V5116 Sgr

Soft continuum with absorption lines
AT REST WAVELENGTH
20 months after outburst
no expansion

=> NLTE WD atmosphere

FIT with
white dwarf atmosphere
models by Thomas Rauch

log g = 9

12 different abundance sets
with
C, N, O, Ne, Mg, Si, S, Ca-Ni enhancements

Model publicly available at
http://astro.uni-tuebingen.de/~rauch/TMAF/flux_HHeCNONeMgSiS_gen.html
V5116 Sgr
RGS spectra HIGH FIT with Rauch's atmosphere models

Simultaneous fit RGS and MOS data constrains $N_H$

$(1-1.6) \times 10^{21}$ cm$^{-2}$

Compatible with ISM $N_H$
V5116 Sgr
RGS spectra HIGH FIT with Rauch's atmosphere models

No model gives a statistically perfect fit
No significant best model
V5116 Sgr
RGS spectra HIGH
FIT with Rauch's
atmosphere models

From confidence ranges of ALL models:

T = (7-8) x 10^5 K
R = (3-9) x 10^8 cm (@ 11 kpc)

### Table 3

<table>
<thead>
<tr>
<th>Model</th>
<th>T$_{eff}$ x10^5 K</th>
<th>K$_{RGS}$ x10^-6</th>
<th>K$_{MOS}$ x10^-6</th>
<th>R x10^8 cm</th>
<th>ISM [O]</th>
<th>N$_H$ x10^21cm^-2</th>
<th>$\chi^2_{nu}$</th>
<th>MOS Flux 0.2-0.7 keV x 10^-10 erg/cm²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>003</td>
<td>7.7</td>
<td>2.5</td>
<td>2.2</td>
<td>5.0</td>
<td>3.8</td>
<td>1.25</td>
<td>2.2</td>
<td>1.25 (+0.05)</td>
</tr>
<tr>
<td>004</td>
<td>7.6</td>
<td>2.9</td>
<td>2.5</td>
<td>5.4</td>
<td>3.5</td>
<td>1.32</td>
<td>2.1</td>
<td>1.25 (-0.08/+0.05)</td>
</tr>
<tr>
<td>005</td>
<td>7.5</td>
<td>3.7</td>
<td>3.2</td>
<td>6.1</td>
<td>3.0</td>
<td>1.44</td>
<td>2.0</td>
<td>1.22 (-0.11/+0.07)</td>
</tr>
<tr>
<td>006</td>
<td>7.3</td>
<td>4.5</td>
<td>3.9</td>
<td>6.7</td>
<td>3.2</td>
<td>1.53</td>
<td>1.9</td>
<td>1.2 (+0.1)</td>
</tr>
<tr>
<td>007</td>
<td>7.3</td>
<td>4.6</td>
<td>4.0</td>
<td>6.8</td>
<td>3.3</td>
<td>1.54</td>
<td>1.9</td>
<td>1.22 (-0.09/+0.06)</td>
</tr>
<tr>
<td>008</td>
<td>7.3</td>
<td>4.6</td>
<td>3.9</td>
<td>6.7</td>
<td>3.6</td>
<td>1.52</td>
<td>1.8</td>
<td>1.22 (-0.1/+0.05)</td>
</tr>
<tr>
<td>009</td>
<td>7.3</td>
<td>4.7</td>
<td>4.0</td>
<td>6.8</td>
<td>3.8</td>
<td>1.52</td>
<td>1.8</td>
<td>1.22 (+0.06)</td>
</tr>
<tr>
<td>010</td>
<td>7.3</td>
<td>4.8</td>
<td>4.1</td>
<td>6.9</td>
<td>4.0</td>
<td>1.53</td>
<td>1.9</td>
<td>1.21 (-0.08/+0.04)</td>
</tr>
<tr>
<td>011</td>
<td>7.3</td>
<td>4.9</td>
<td>4.2</td>
<td>7.0</td>
<td>4.2</td>
<td>1.53</td>
<td>1.9</td>
<td>1.21 (-0.06/+0.05)</td>
</tr>
<tr>
<td>201</td>
<td>7.9</td>
<td>1.8</td>
<td>1.6</td>
<td>4.3</td>
<td>5.0</td>
<td>1.11</td>
<td>2.1</td>
<td>1.24 (+1.24??)</td>
</tr>
</tbody>
</table>
V5116 Sgr
RGS spectra HIGH FIT with Rauch's atmosphere models

Simultaneous fit RGS and MOS data
V5116 Sgr
RGS spectra HIGH
FIT with Rauch's
atmosphere models

Atmosphere
fits well
N VII α
N VII β
O VII α

New TBabs
absorption model
(Wilms et al 2011)
fits well

O I 1s-2p
V5116 Sgr
RGS spectra HIGH
FIT with Rauch's atmosphere models

BUT even new TBabs still fails to fit well the O K-edge complex

complicated contributions of ISM
V5116 Sgr
RGS spectra HIGH
FIT with Rauch's
atmosphere models

ATMOSPHERE
model fails to fit
N VII α PROFILE;
red wing excess

Contribution from
N VI β
In emission ??

Let's see spectrum
during “LOW”!!
V5116 Sgr: RGS spectra
LOW

- N VIIβ
- O VIIα
- N VIIα
- (N VIγ) -
- N VI β
- ?? -
- (C VIγ) -
- ?? -
- N VI α -
- N VI f -
- N I -

channel wavelength (Angstrom)
Fainter soft continuum with absorption lines (atmosphere) plus emission lines (plasma)
- at rest wavelength
- N enhancement, but not C

Fit with same atmosphere as HIGH but fainter, plus collisional plasma model VAPEC
V5116 Sgr: RGS in LOW flux

Atmosphere a factor 8 fainter than in HIGH

Plasma (ejecta) now not overshined.

kT=0.11 keV

N enriched \([N]>300\)

No significant C or O
V5116 Sgr
BACK TO HIGH

ATMOSPHERE model fails to fit N VII α PROFILE;
red wing excess

Contribution from N VI β In emission ??

TRY IF APEC AS IN LOW FITS N VI line
V5116 Sgr

BACK TO HIGH

ATMOSPHERE model fails to fit N VII α PROFILE;

red wing excess

Contribution from N VI β In emission => YES!

APEC AS IN LOW FITS N VI line, explains N VII red wing excess
V5116 Sgr
BACK TO HIGH

APEC
AS IN LOW
FITS N VI line
WHILE BEING
COMPATIBLE WITH
DATA AT OTHER
WAVELENGTHS
V5115 Sgr = Nova Sgr 2005a

Discovered on 2005 March 28.8, with $V \sim 8.7$

Reached maximum on March 30.12, $V \sim 7.7$

E(B-V): 0.5-0.6

**DISTANCE DETERMINATION:**

We need:
1. time to decrease 2 mag, ($t_2 = 8 \pm 1$ days) and
2. observed magnitude at maximum.

Using Della Valle & Livio (1995) $M_V - t_2$ relation, $d \sim 10$ kpc

Using Buscombe -de Vaucouleurs (1955) relation, $d \sim 15$ kpc

*(Ederoclite & Mason 2006, RS Oph meeting)*
V5115 Sgr. SSS with hard excess. Does a plasma model (APEC) fit the excess?

Atmosphere $T=7.8\times10^5$ K

Atmosphere $T=7.8\times10^5$ K
+ Plasma $kT=0.5$ keV
V5115 Sgr. The grating spectrum

Atmosphere $T = 7.8 \times 10^5$ K

+ Plasma $kT = 0.5$ keV
Summary

- Both **V5115 Sgr** and **V5116 Sgr** show two components in their X-ray spectra: WD atmosphere and collisional plasma.

- “Old” novae, not expanding anymore, features at rest wavelength.

- NLTE WD atmosphere models and plasma models provide reasonably good fits (but some features unexplained).

- Also ISM absorption models (TBnew) fail to fit all observed ISM features
V5116 Sgr

- **X-ray lc period = optical (orbital) period.** But dip during 2/3 of the orbit incompatible with eclipse by the secondary => accretion disk obscuring the WD for 2/3 of the orbit: let us see WD and ejecta components with changing contributions.

- **Same atmosphere temperature** in low and high flux (indicating obscuration effect rather than intrinsic change in the WD emission).

- **RGS spectra:**
  
  Lines at rest wavelength. N enhancement.
  
  **High flux period:** Atmosphere plus some residuals explained by plasma component as seen in “low”
  
  **Low flux period, dip:** Fainter (1/8) atmosphere plus collisional plasma emission from ejecta

=> from ejecta, enhanced N, not so much C