Update on the White Dwarf (+ iNS) Working Group

Vadim Burwitz
International Astronomical Consortium for High Energy Calibration
Apr. 10-14 2011, Frascati, Italy
WG Members

• **White Dwarfs** *(Chair: Vadim Burwitz).*
  Current members:
  - J. Drake (Chandra),
  - F. Haberl (XMM-Newton/EPIC-pn),
  - J. Kaastra (Chandra/LETG and XMM-Newton/RGS),
  - H. Marshall (Chandra/HETG),
  - N. Schultz (Chandra/HETG).

• **Isolated Neutron Stars** *(Chair: Frank Haberl).*
  Current members:
  - A. Beardmore (Swift/XRT),
  - V. Burwitz (XMM-Newton/EPIC-pn, Chandra/LETGS),
  - J. Cottam (XMM-Newton/RGS),
  - C. de Vries (XMM-Newton/RGS),
  - T. Dotani (Suzaku),
  - E. Miller (Suzaku/XIS),
  - S. Sembay (XMM-Newton/EPIC-MOS).
Overview

• Why White Dwarfs and iNS

• Isolated Neutron Stars
  → WG little activity since last 2 IACHECs

• White Dwarfs
  → in full action, busy completing analysis of reprocessed and new data HZ 43, Sirius B and GD153 using CIAO 4.3 CALDB 4.4.3

• Status of home work from IACHEC 2010!
Why calibration at soft X-rays

- Absolute Calibration between
  - Chandra, XMM, ROSAT, EUVE

- Important for better as diverse objects as:
  - White Dwarfs
  - Magnetic CVs
  - Novae
  - Supersoft sources
  - Diffuse emission
  - Soft end of spectra of INS and bright powerlaw sources
RX J0513-69 vs. other Super-soft sources

Beuermann in Trümper & Hasinger 2008
RX J0513-69 LETGS spectra

Burwitz et al. 2010 in prep.
LB1919 and GD146

Adamczak et al. 2010

$T_{\text{eff}} = 56\,000\,\text{K}, \log g = 8.5$
metal poor DA white dwarf

$T_{\text{eff}} = 52\,000\,\text{K}, \log g = 8.5$
diffusion

$T_{\text{eff}} = 55\,000\,\text{K}, \log g = 7.3$
homogeneous
DA white dwarf

$T_{\text{eff}} = 55\,000\,\text{K}, \log g = 7.9$
diffusion
**PG 1520+525**

Adamczak et al. 2010

**PG 1520+525: He, C, O, Ne, Mg, log g = 7.5**  
a non-pulsating PG 1159 star

\[ T_{\text{eff}} = 140,000 \text{ K} \]

\[ T_{\text{eff}} = 150,000 \text{ K} \]

\[ T_{\text{eff}} = 160,000 \text{ K} \]
Absolute Calibration at Soft X-rays

• is dependant on model spectra of WDs and iNS
• what models to use? → physical vs. descriptive
• uncertainties?

Beuermann et al. 2006, A&A 458, 541

Detailed iNSs were given at the last IACHEC #5 by
→ Valery Suleimanov

This will be detailed WDs in the next talk today by
→ Thomas Rauch
### Parameters obtained from fit

**Beuermann et al. 2006, 2008**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value ± Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) <strong>HZ43 A</strong> ($\lambda = 45 - 160$ Å)</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{eff}}$ (K)</td>
<td>51126 ± 660</td>
</tr>
<tr>
<td>log $g$</td>
<td>7.90 ± 0.08</td>
</tr>
<tr>
<td>$R^2/d^2$ ($10^{-23}$)</td>
<td>3.011 ± 0.010</td>
</tr>
<tr>
<td>$N_{\text{H}}$ ($10^{17}$ cm$^{-2}$)</td>
<td>8.91 ± 0.37</td>
</tr>
<tr>
<td>(b) <strong>Sirius B</strong> ($\lambda = 74 - 160$ Å)</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{eff}}$ (K)</td>
<td>24923 ± 115</td>
</tr>
<tr>
<td>log $g$</td>
<td>8.6 $f^1$</td>
</tr>
<tr>
<td>$R^2/d^2$ ($10^{-21}$)</td>
<td>4.877 ± 0.010</td>
</tr>
<tr>
<td>$N_{\text{H}}$ ($10^{17}$ cm$^{-2}$)</td>
<td>6.5 ± 2.0 $^2$</td>
</tr>
<tr>
<td>(c) <strong>RX J1856</strong> ($\lambda = 15 - 74$ Å)</td>
<td></td>
</tr>
<tr>
<td>$kT_{\text{spot}}$ (eV)</td>
<td>62.83 ± 0.41</td>
</tr>
<tr>
<td>$kT_{\text{star}}$ (eV)</td>
<td>32.26 ± 0.72</td>
</tr>
<tr>
<td>$R_1/d$ (km/pc)</td>
<td>0.0378 ± 0.0003</td>
</tr>
<tr>
<td>$R_2/d$ (km/pc)</td>
<td>0.1371 ± 0.0010</td>
</tr>
<tr>
<td>$N_{\text{H}}$ ($10^{20}$ cm$^{-2}$)</td>
<td>1.10 ± 0.03</td>
</tr>
</tbody>
</table>

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$^1$ Based on Barstow et al. (2005); Holberg et al. (1998)

$^2$ Hébrard et al. (1999). Our fit is required to stay within the 1-$\sigma$ error.

**Table 2.** Parameters of HZ43 A, Sirius B, and RX J1856 based on the simultaneous fit of our model spectra to the LETG+HRC count rate spectra in the wavelength intervals given. The quoted 1-$\sigma$ ($\Delta \chi^2 = +1$) errors are correlated and derived from fits with the other parameters for each object kept free. The letter $f$ indicates: fixed.
Simultaneous fit to RXJ1856 and the WDs

Fig. 5. Simultaneous fit of RXJ1856, HZ43 A, and Sirius B in the wavelength ranges marked by vertical dotted lines (see Sect. 4.4.2). The LETG spectra binned to 0.5 Å are shown as data points, the corresponding best-fit models as solid curves, and the first-order contributions as dashed curves. The area correction function $\alpha$ is shown at the top. It converts the nominal LETG+HRC-S first-order effective area $A^0$ of the November 2004 release into the adjusted area $A$ used in this paper. Systematic uncertainties in $\alpha$ are indicated by error bars at 46, 70, 90, and 125 Å. The steps in the count rate spectra of HZ43 A and RXJ1856 at 49 and 69 Å result from the detector gaps. Sirius B was observed off axis and its gaps are located differently (see text).

Beuermann et al. 2006, 2008
Comparison of photon spectra

Beuermann et al. 2006, 2008
Comparison of EUVE data of WDs

HZ43
Sirius B
GD 153

Teff ~ 51100 K
Log g ~ 7.95
D ~ 63 pc
15.3 mas

Teff ~ 24900 K
Log g ~ 8.6
D ~ 3 pc
379 mas

Teff ~ 38000 K
Log g ~ 7.87
D ~ 69 pc
HZ43, Sirius B and GD153
Correction function for LETGS
HZ43, Sirius B and GD153

![Graph showing normalized counts vs. wavelength for HZ 43 A, Sirius B, and GD153 with corresponding ratios.]
Reprocessed Chandra LETGS HZ43, Sirius B and GD153 white dwarf Spectra

<table>
<thead>
<tr>
<th>Target</th>
<th>$nH$ [10$^{22}$ cm$^{-2}$]</th>
<th>$T$ [K]</th>
<th>Norm</th>
<th>$\log g$ [cm/s$^2$]</th>
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<tbody>
<tr>
<td>GD 153</td>
<td>$&lt;3.2 \times 10^{-4}$</td>
<td>41000</td>
<td>0.50</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>+/- 2000</td>
<td>+/- 0.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HZ 43</td>
<td>$&lt;2.6 \times 10^{-4}$</td>
<td>49800</td>
<td>1.12</td>
<td>7.9</td>
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<tr>
<td></td>
<td>+/- 2200</td>
<td>+/- 0.43</td>
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<tr>
<td>Sirius B</td>
<td>$&lt;2.5 \times 10^{-4}$</td>
<td>25300</td>
<td>117</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>+/- 300</td>
<td>+/- 16</td>
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### Chandra LETGS HZ43 observations

<table>
<thead>
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<th>Obs ID</th>
<th>Date</th>
<th>Exp (ks)</th>
<th>GTI (ks)</th>
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<tr>
<td>00059</td>
<td>1999-11-12</td>
<td>40</td>
<td>35</td>
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<tr>
<td>01011</td>
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<td>02584</td>
<td>2002-01-01</td>
<td>20</td>
<td>16</td>
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<td>02585</td>
<td>2002-07-23</td>
<td>20</td>
<td>18</td>
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<td>03676</td>
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<td>05959</td>
<td>2005-07-29</td>
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<td>06473</td>
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<td>2009-03-18</td>
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<tr>
<td>11933</td>
<td>2010-03-15</td>
<td>20</td>
<td>17</td>
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**Total** 340
HZ43 on-axis 2007-2010
HZ43 on-axis 1999-2010
HZ43 time dependence
HZ43 time dependence
### Chandra LETGS Sirius B observations

<table>
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<th>Obs ID</th>
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<tr>
<td>01421</td>
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<td>14</td>
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<tr>
<td>01452</td>
<td>1999-10-26</td>
<td>28</td>
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<tr>
<td>01459</td>
<td>1999-10-27</td>
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*off axis observations*

<table>
<thead>
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<th>Obs ID</th>
<th>Date</th>
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<td>09617</td>
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*on axis observations detector edge*

<table>
<thead>
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<th>Obs ID</th>
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<td>09815</td>
<td>2008-05-26</td>
<td>51</td>
<td>50</td>
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*on axis observations*

**Total** 163 126
Sirius B ratio on-axis
Sirius B ratio off-axis
Chandra LETGS **GD153** observations

<table>
<thead>
<tr>
<th>Obs ID</th>
<th>Date</th>
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<th>GTI (ks)</th>
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<tbody>
<tr>
<td>11805</td>
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<td>24</td>
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<tr>
<td>12132</td>
<td>2010-03-30</td>
<td>45</td>
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<tr>
<td>12133</td>
<td>2010-04-01</td>
<td>49</td>
<td>46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>119</strong></td>
<td><strong>98</strong></td>
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</table>
GD153 ratio on-axis
Home work from IACHEC 2009

- Discuss possible Chandra LETGS improvements with Chandra calibration Group
  - influence of new HRMA effective areas ...
- Analyse LETGS data on
  - Sirius B (50ks on-axis and 50ks off-axis observations)
- GD153 110ks observation in the queue
  - Prepare grid of models (Lanz, Rauch)
  - analyse data as soon as available.
- Provide WD spectra in xspec format on web
- Improve link to iNS RXJ1856
Home work from IACHEC 2009

- Discuss possible Chandra LETGS improvements with Chandra calibration Group
  - influence of new HRMA effective areas ...

- Analyse LETGS data on
  - Sirius B (50ks on-axis and 50ks off-axis observations)

- GD153 110ks observation in the queue
  - Prepare grid of models (Lan) ...
  - analyse data as soon as available

- Provide WD spectra in xspec format on web

- Improve link to iNS RXJ1856

GD153 110ks LETGS Observation just performed
Home work from IACHEC 2009/2010

- Discuss possible Chandra LETGS improvements with Chandra calibration Group
  - influence of new HRMA effective areas ...

- Analyse LETGS data on
  - Sirius B (50ks on-axis and 5ks off-axis)

- GD153 110ks observation in the queue
  - Prepare grid of models (Lamers et al. 2005)
  - analyse data as soon as available

- Provide WD spectra in xspec format on web

- Improve link to iNS RXJ1856

@ Vadim Burwitz

GD153 110ks LETGS Analysis in full swing

Sirius B on/off axis LETGS comparison beeing done
Summary

→ Other Calibration Observations

• Chandra Calibration data
  → Sirius B in 2008 (off axis, on axis).
  → HZ 43 regular observations
  → no Chandra LETGS INS RXJ1856 observation has been done since the 500 ks observation, XMM and SWIFT observe it regularly.

→ Recent observations

• Joint SRON (Kaastra) /MPE (Predehl) /CXC (Murray)
  → 110 ks Chandra LETGS observation of the white dwarf GD153 results presented here

• WG Meeting
  → Meet to discuss about the GD153 data and reprocessed observations.