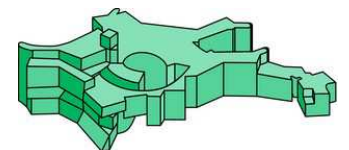


X-ray diagnostics of chemical composition of the accretion disk and donor star in UCXBs II: **XMM Observations**

F. Koliopanos, M. Gilfanov, L. Bildsten & M. Diaz Trigo
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Speaker:

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Max-Planck-Institut
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Ultra Compact X-ray Binaries

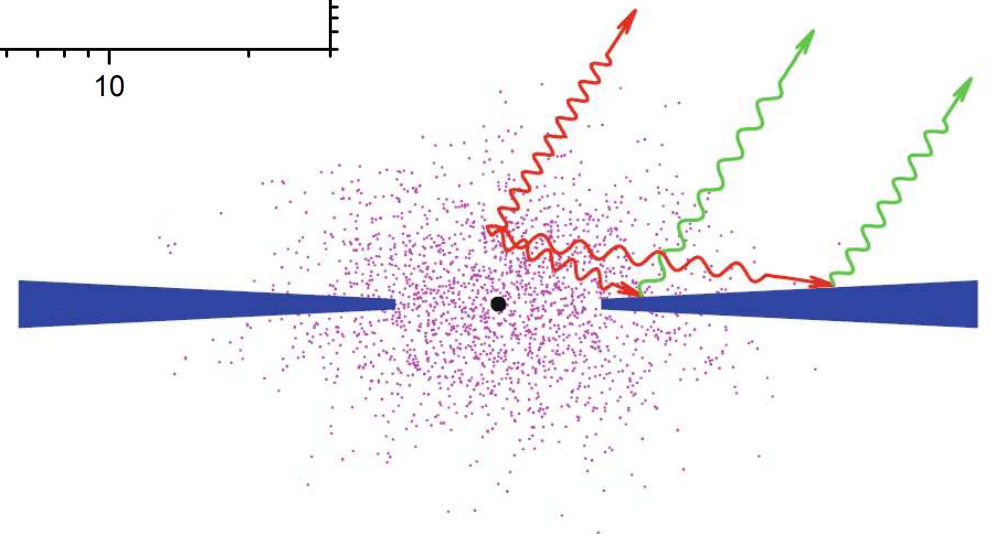
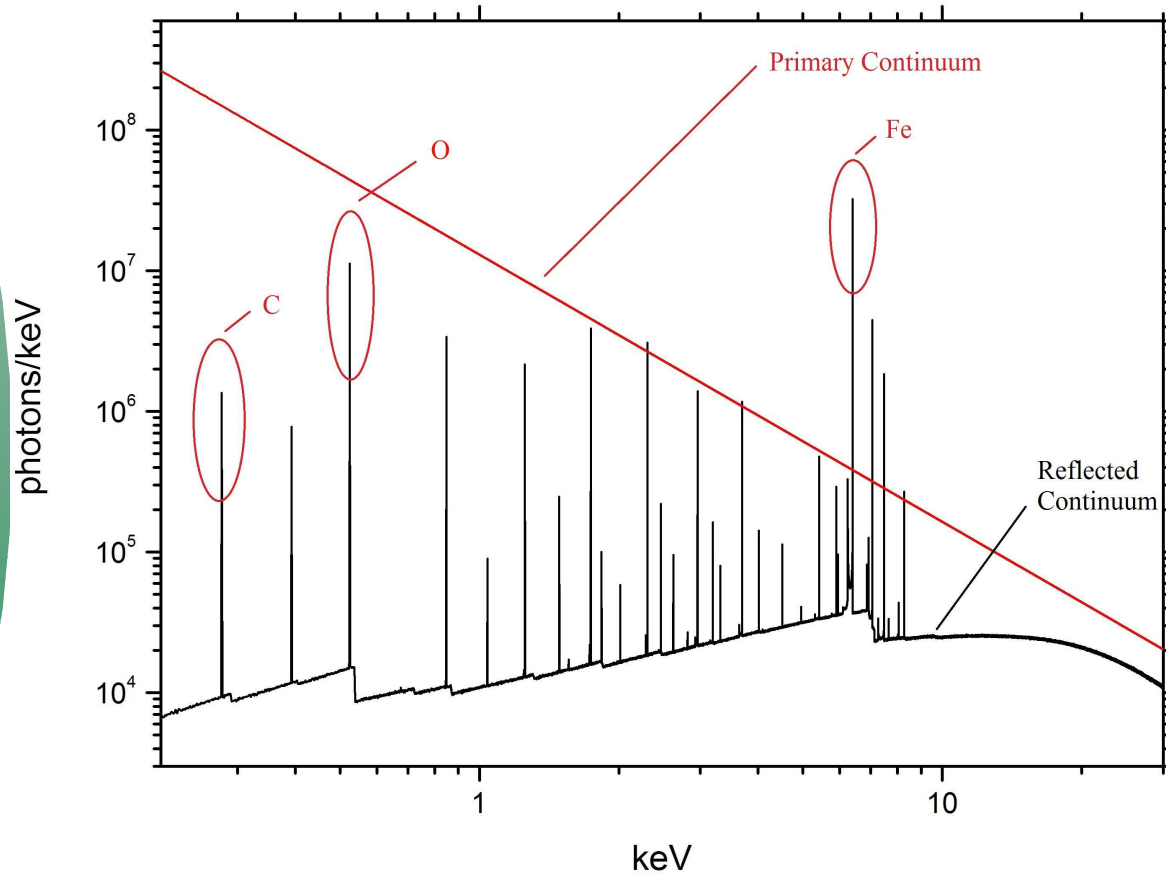
- Ultra compact X-ray binaries (UCXBs) are a sub-group of X-ray binaries with orbital periods of less than 1 hour.
- Small orbital periods do not allow for a hydrogen rich, main sequence donor.
- White dwarf (WD) or helium star accreting onto a neutron star (NS).
- Persistent and relatively high X-ray luminosities in the 10^{35} – 10^{38} erg s⁻¹ range.

Composition

- Different initial parameters and the environment of UCXB progenitors may lead to a variety of donors.
- Two broad categories:
 - i) **He rich**
He=0.99, C=0.0052, N=0.0016, O=0.0018 (*Pandey et al., 2001*)
 - ii) **C/O/Ne/Mg-rich**
C = O \approx 0.49 and Ne \approx 0.02 (*e.g. Garcia-Berro et al., 2008*)

Ne \approx 0.28, O \approx 0.55, Mg \approx 0.05, Na \approx 0.06 (*Gil-Pons and García-Berro, 2001*)

X-ray reflection



Theoretical predictions

(Koliopanos, Gilfanov and Bildsten 2013)

For an incident **power law** spectrum with $\Gamma=1.9$

- Solar – like composition:
Equivalent width of iron K_α line: **EW ~ 100 eV**
- **C/O/Ne/Mg – rich** composition:
Equivalent width of iron K_α line: **EW ~ 3 – 7 eV**
- **He – rich** composition:
Equivalent width of iron K_α line: **EW ~ 100 eV**
- **Absence** of a strong K_α line of iron at 6.4 keV should be considered as an indication of a **C/O/Ne** white dwarfs whereas the **presence** of such a line points to a **He**-rich donor.

Observations

- We search for the **Fe K α line** in the spectra of **UCXBs**.
- 14 confirmed Ultra Compact X-ray Binaries.
- We analyze all available *XMM* observations.
- We choose 5 observations to be fitted with XSPEC.
- Selection criteria based on the simplicity of their spectral continuum.
- We ignore energy channels below 2.5keV
- High energy spectral continuum fitted with **Absorbed power law**
- We report the bursting activity of each source.
- Recurrent short and intermediate **Type I X-ray** bursts should be fueled by He accretion.

Observations

- **No Fe K_{α} line:**

2S 0918-549: EW upper limit: **7eV**
- Suggested **C/O-rich** disk (Nelemans et al. 2004)

7 Bursts recorded

XTE J1807-294: EW upper limit: **10eV**
- We attribute lack of Fe line to **C/O** or **O/Ne** rich disk

No bursts

4U 0513-40: EW upper limit: **20eV**
- We attribute lack of Fe line to **C/O** or **O/Ne** rich disk

9 Bursts recorded

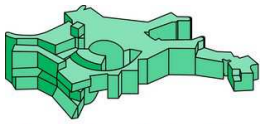
- **Bright Fe K_{α} line:**

4U 1916-05: EW = **95eV¹**
- Optically confirmed **He-rich** disk (Nelemans, Jonker & Steeghs 2006)

Burster: 6.2hr recurrence

4U 0614+091: EW = **111eV**
- Optically confirmed **C/O-rich** disk (Nelemans et al. 2004; Werner et al. 2006)

Burster: 10d recurrence



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- Suggeste

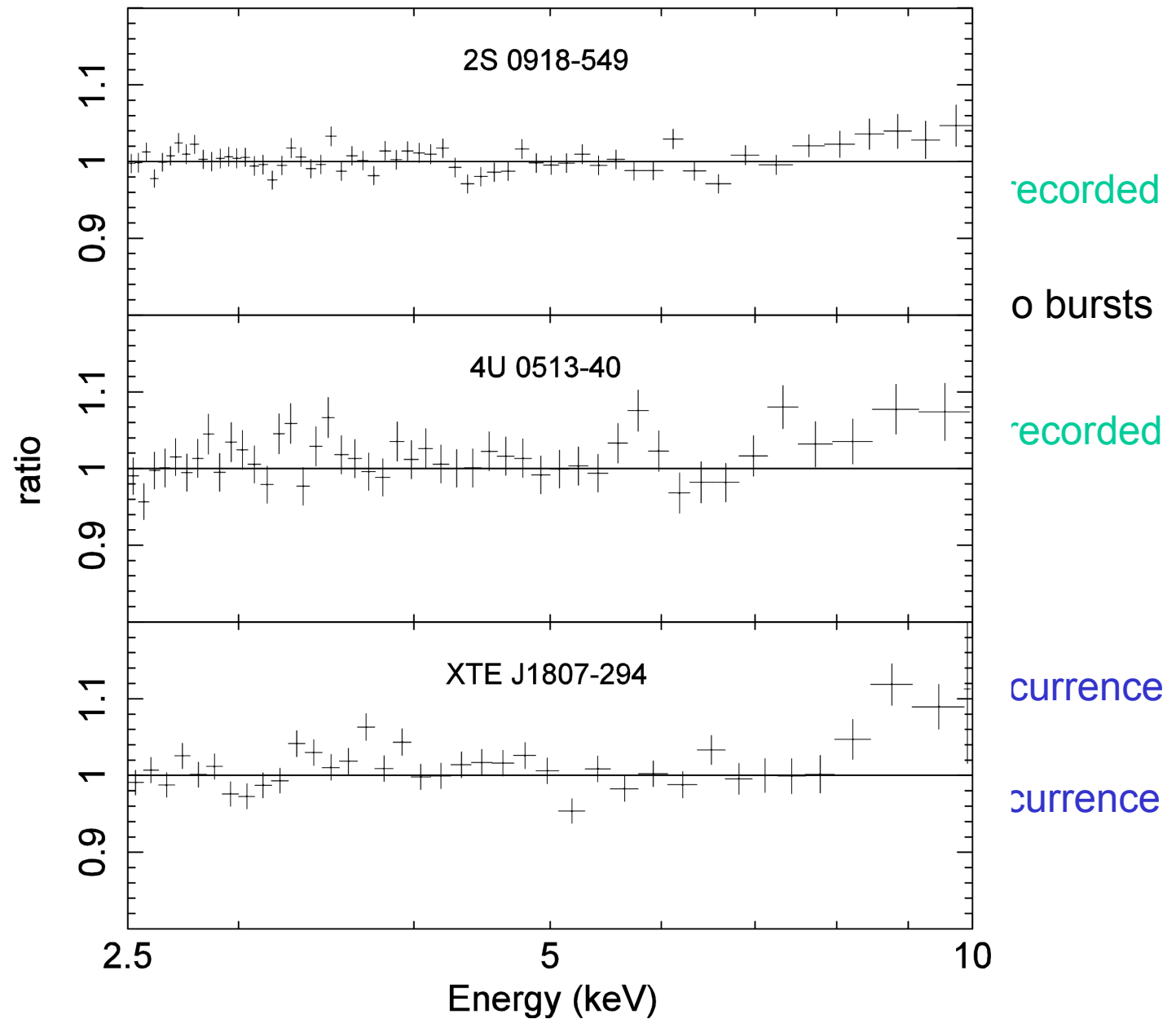
XTE J18
- We attribu

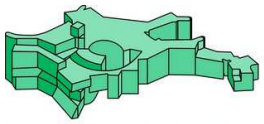
4U 0513
- We attribut

• **Bright F**

4U 1916
- Optically c

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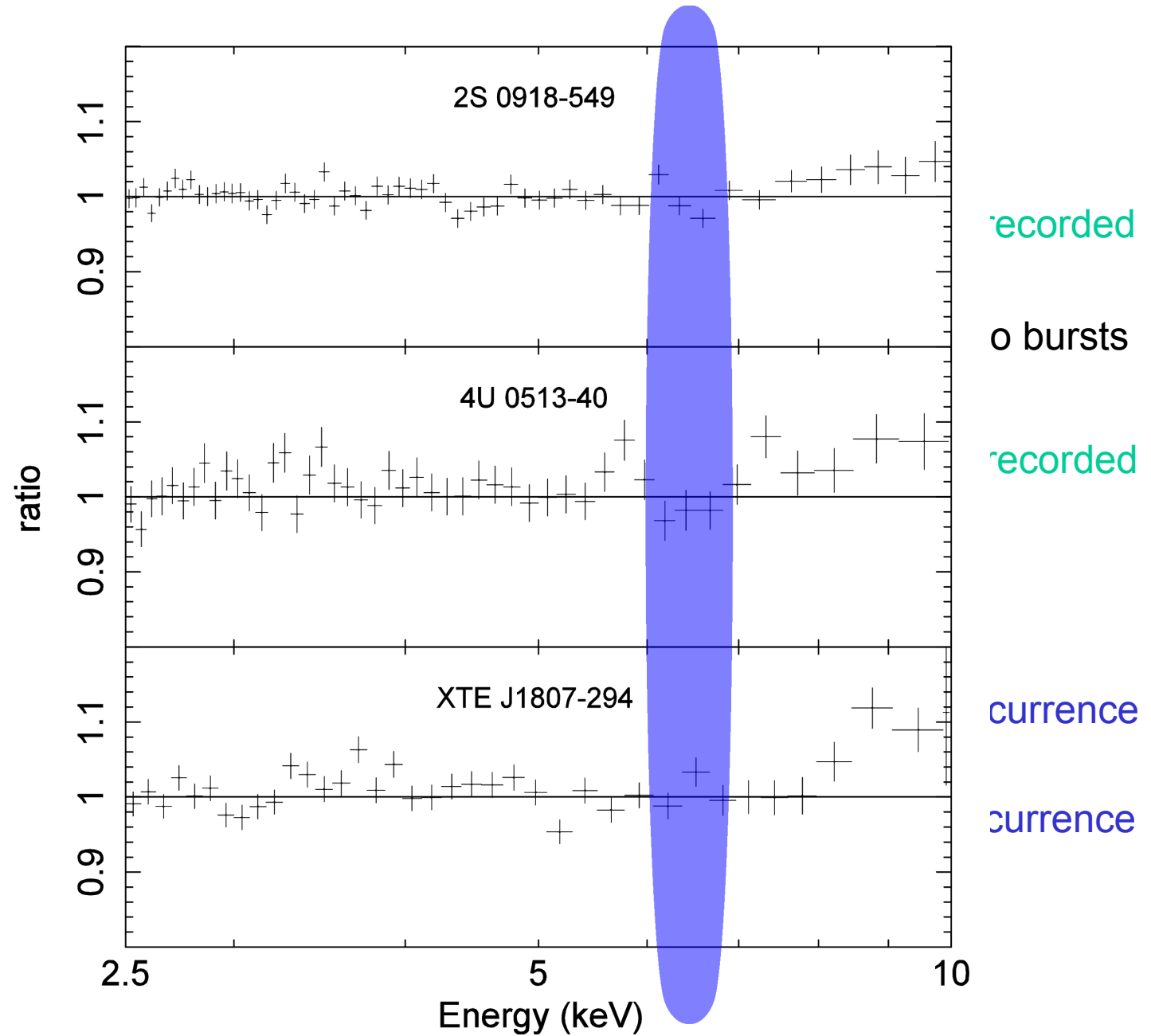
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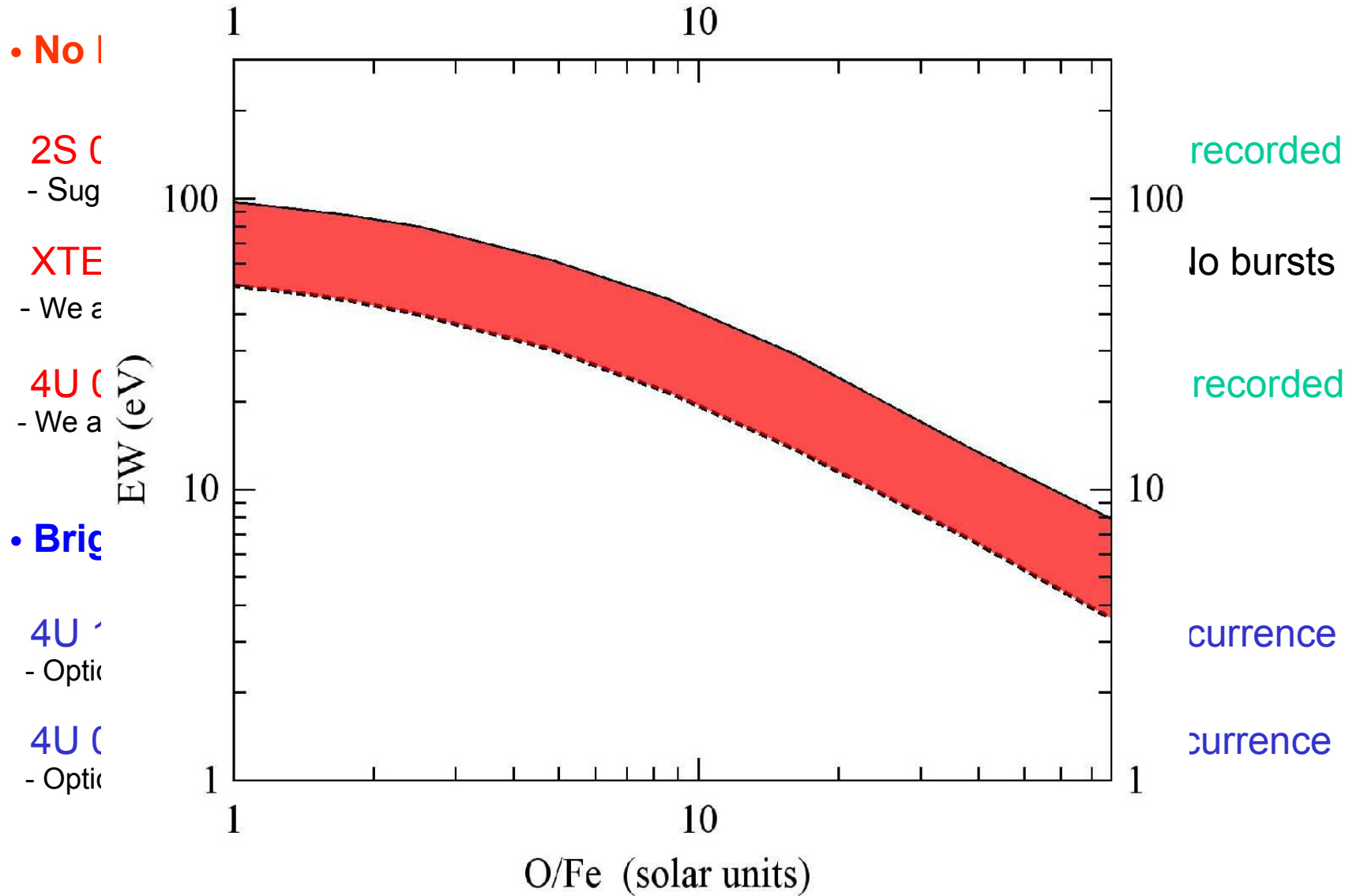
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• **No Fe**

2S 091
- Suggest

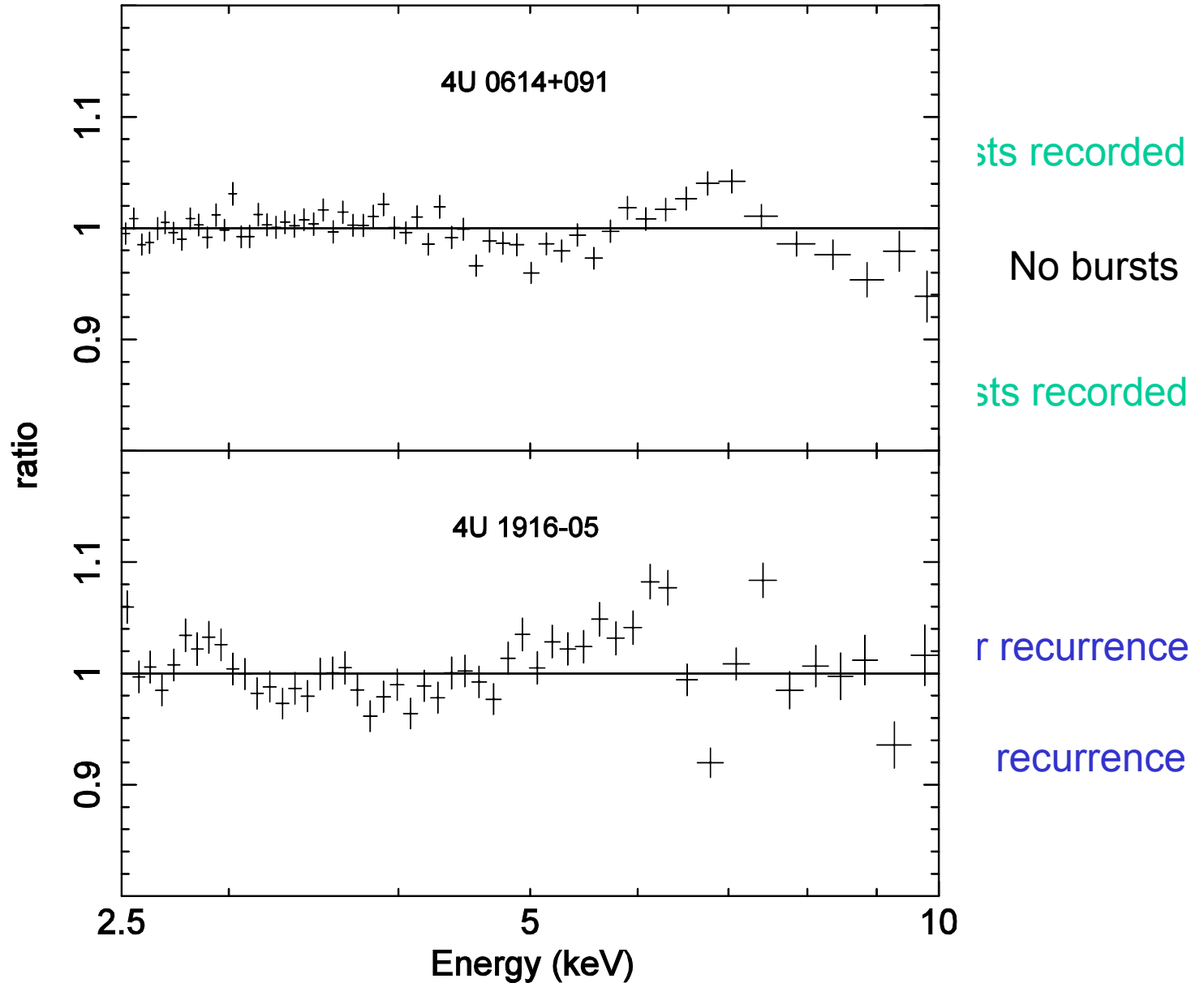
XTE J1
- We attri

4U 051
- We attri

• **Bright**

4U 191
- Optical

4U 061
- Optical



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Burster: 10d recurrence

- **Indications of C/O-rich donor:**

- **Absence** of **He** or **H** lines in the optical spectrum. Non-LTE accretion disk model places **upper limit** of **10%** on the abundance of **H** and/or **He** in the disk.

(Nelemans et al. 2004; Werner et al. 2006)

- **Presence** of very broad, emission-like residuals at ~ 0.7 keV can be interpreted as **O VIII** fluorescence line due to reflection from a **C/O-rich disk**.

(Schultz et al. 2010, Madej et al. 2010, 2014)

- **Indications of He-rich donor**

- **Presence** of strong Fe K α line in the X-ray spectrum suggests a **He-rich disk**.

(Koliopanos et al. 2013, this work)

- **Frequent X-ray bursts**. **He** ignition and small changes in accretion rate can explain frequent short and intermediate bursts. Bursts occur at a **10d recurrence**, thus requiring copious amounts of fuel.

(Kuulkers et al. 2010; Linares et al. 2012)

Summary and Conclusions

Model predictions:

- We have taken the first steps at modeling X-ray reflection spectra from **He**-rich and **C/O/Ne/Mg** rich disks of UCXBs (Koliopanos et al. 2013).
- The Fe K α line can be used as a diagnostic test for the chemical composition of the accretion disk and donor star in UCXBs. Namely:
 - **C/O/Ne/Mg** – rich disks feature a very faint line if any.
 - **He** – rich disks feature a bright iron line similar to the hydrogen rich spectra.

Observational conclusions:

- **Absence** of significant Fe line in the spectra of **2S 0918-549**, **XTE J1807-294** and **4U 0513-40** indicates a **C/O/Ne/Mg** – rich donor
- **Presence** of strong Fe line in **4U 1916-05** and **4U 0614+091** indicates a **He-rich** donor.
- **4U 0614+091**: Contradiction between our result and those of optical spectroscopy could be resolved if He is full ionized.