Timing and spectral view on accretion disk truncation radius

Ilya Mereminskiy, IKI RAS, Moscow
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Keeping the eye on the Galaxy
GRS 1739-278 in 2016

\[ \Gamma \approx 1.9 \]
X-ray novae states

Kylafis+15
X-ray novae states

Kylafis+15
X-ray novae states

Kylafis+15
GRS 1739-278 in 2014

Trigger by BAT/INTEGRAL!
GRS 1739-278 in 2014

Caught at transition?
...in low-hard state!

Jon Miller et al., 2015
Peculiar low-hard state!

\[ R_{tr} < 5 \ (+4,-3) \ R_g \]

Miller et al., 2015
reline_lp

$h = 3 \, r_g$
$h = 10 \, r_g$
$h = 25 \, r_g$
$h = 50 \, r_g$
$h = 100 \, r_g$
$h = 500 \, r_g$

$a = +0.99$

Energy [keV]

Flux [a.u.]

Dauser+2010, Dauser+2016
Averaged spectrum

\[ R_{\text{tr}} < 7.4 R_g \]
Closer look at data
Closer look at data

Movement of $R_{tr}$?
Closer look at data

Movement of $R_{tr}$?
Closer look at data

![Graph showing data trends over orbit numbers](image)
Closer look at data

Reflected component do not change
..timing, maybe?
QPO, cospectra

2.3 times!
LF QPO – Lense-Thirring precession?

Stella & Vietri 98, 99
Ingram + 09,
Veledina + 13
LF QPO – Lense-Thirring precession

Frequency depends on BH mass, spin and $R_{tr}$

Stella & Vietri 98, 99
Ingram & co-authors 09, 13
Spectra-timing

The graph shows the relationship between $f_{QPO}$ (Hz) and $R_{in}$ (GM/c^2) for different mass and spin configurations.

- Red dashed line: $10 M_\odot$, $a = 0.1$
- Red solid line: $10 M_\odot$, $a = 0.998$
- Green dashed line: $30 M_\odot$, $a = 0.1$
- Green solid line: $30 M_\odot$, $a = 0.998$

The orange rectangle highlights the region of interest for practical applications.
Spectra-timing

- Graph showing the relationship between frequency ($f_{\text{QPO}}$, Hz) and inner radius ($R_{\text{in}}$, GM/c²) for different mass and spin values:
  - $10 \, M_\odot$, $a = 0.998$ (red dashed line)
  - $30 \, M_\odot$, $a = 0.998$ (green dashed line)
  - $10 \, M_\odot$, $a = 0.1$ (red solid line)
  - $30 \, M_\odot$, $a = 0.1$ (green solid line)

Mereminskiy+19
Spectra-timing

Mereminskiy+19
Skeptics conclusion

\[
\text{XOR} \left\{ \begin{array}{c}
\text{RPM} \\ 
R_{tr} \\
\end{array} \right. \text{ from reflection}
\]
GX 339-4

\[ M = 9 M_\odot \]
\[ M = 75 M_\odot \]
\[ M = 100 M_\odot \]
\[ M = 200 M_\odot \]
\[ a = 0.1, M = 9 M_\odot \]

\[ \nu_{\text{nod}} \text{ (Hz)} \]

Furst et al., 2016

\[ M_{\text{BH}} = 9^{+1.5}_{-1.2} M_\odot \]
MAXI J1535-571

MAXI+BAT spectra!
MAXI J1535-571

[Graph showing flux versus MJD with different data sets represented by Swift-XRT, NuSTAR, INTEGRAL, Swift/BAT, 15-50 keV, and MAXI, 2-4 keV and 4-10 keV]
MAXI J1535-571

Xu et al., 2017

30 M☉, a = 0.84

Xu et al., 2017

Mereminskiy+18
Conclusions

Measurements of $R_{tr}$ from reflected spectra and RPM models cannot be simultaneously correct

Reflection models need independent verification! (Poutanen+2018, etc)

INTEGRAL provides unique data on initial stages of X-ray novae outbursts

Thank you for attention!