Emission Lines From Tidally Disrupted White Dwarfs And Other Evolved Stars

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Emission Lines Form TDEs

- Aid in identification of tidal disruption events
- Characterization of disruption scenario
 - · BH mass/spin
 - Disrupted star

Bogdanovic et al. (2004) Roos (1992)



White Dwarf Tidal Disruptions

Signpost of intermediate mass black holes:

 $R_T < R_S$ when $M_{\rm BH} \gtrsim 10^5 M_{\odot}$

 Proceeded/accompanied by a gravitational wave signal

Kobayashi et al. (2004)

Sesana et al. (2008)

Haas et al. (2012)

 Thermonuclear reactions possible in strong encounters

Rosswog et al. (2009)

Dynamical Model

- We adapt the model derived by Strubbe & Quataert :
- Star on a parabolic orbit with $R_p < R_T$
- Bound material forms a standard α -disk with accretion efficiency of 10% and :

$$\dot{M} \sim \dot{M}_{\rm fb} \propto t^{-5/3}$$



Strubbe & Quatart (2009)

Dynamical Model

 We consider points along the entire wedge:

$$R(\phi) \sim v_p t \cot\left(\frac{\phi}{2}\right)$$

• n(R,t) ~ R⁻³





- Multicolor Blackbody
- Multicolor Blackbody + X-ray power law
- Multi-component AGN





 $M_{\rm WD} = 0.55 \ M_{\odot}$ $R_{\rm WD} = 8.6 \times 10^8 \ {\rm cm}$

Label	$M_{BH}~(M_{\odot})$	R_P/R_T	R_{LSO}/R_S
A	10 ²	1	3
в	10^{2}	0.3	3
C	10^{3}	1	3
D	10^{3}	0.3	3
E	10^{3}	1	0.5
F	104	1	3

Emission Line Profiles



 We know the flux and velocity along the illuminated face so we can compute the emission line profiles

Emission Line Profiles





Results

 The model predicts that when a WD is tidally disrupted, the accretion flare will be accompanied by:

- \cdot CIV 1549 emission lines with $L_{\text{line}} \sim 10^{38} \text{ erg/s}$ early on
- [O III] 5007 lines with luminosity of up to L_{line} ~ 10³⁷ erg/s at late times
- These lines will have FWHM 2-3 thousand km/s and be asymmetric

Has This Been Observed?

- ULX in an NGC 4472 globular cluster
- The measured [OIII] 5007 luminosity is consistent with the model
- · L5007= 1.4 x 10³⁷ erg/s

 Line has a width of 2000 km/s Zepf et al. (2008)



Has This Been Observed?



Has This Been Observed? But...

- ROSAT measured the X-ray luminosity of the source to be 5 x 10³⁹ erg/s in 1994
 Colbert & Ptak (2002)
- This means that the [O III] 5007 luminosity measurements by Zepf et al. (2008) were made at least 14 years after tidal disruption, long after the our predicted peak in the [O III] 5007 light curve at ~2 years after disruption
- Source was not detected in Chandra or Swift observations in 2008 and 2010

Maccarone et al. 2010

Unlikely that this is a WD tidal disruption

Has This Been Observed?



Ultraluminous X-ray source in an NGC 1399 GC
Irwin et al. 2010
Emission line FWHM ~ 140 km s⁻¹

Horizontal Branch Stars



Emission Line Light Curves





UV Emission Lines



Tidal Disruption Of A Stripped He Core



Tidal Disruption Of A Stripped He Core



Summary

- Broad, asymmetric C IV 1549 and [O III] 5007 emission lines can indicate WD tidal disruption if:
 - Lines coincide with a UV/X-ray flare at the center of a globular cluster or galaxy
 - There are not hydrogen lines in the spectrum
- \cdot X-ray luminosity and emission lines from ULX in NGC 1399 GC agree with model of a HB star that has been disrupted by a 50 200 M_{\odot} black hole.
- Where are the hydrogen lines in MS disruptions?