A Unified Model of Low Mass X-ray Binaries

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LMXB are a major class of X-ray source driven by accretion displaying various states.

The nature of these states and of LMXB have not been understood.

The key to solving the problem:

Has been the eventual realization that the Comptonizing region is an extended Accretion Disk Corona above the accretion disk.

The proof of this:

Is now very secure based on two completely independent techniques:

1) determining the size by timing the ingress to absorption dips. The Comptonized emission is removed part by part showing its extended nature [ref. 2]

2) The work of Schulz and colleagues showing that line emission originates in the highly ionized ADC at large radial positions via the Doppler shifts due to orbital motion in the ADC [ref. 3].

The critical consequence of extended ADC

Is that it determines the spectrum of the Comptonized emission [ref. 2]

The seed photons:

Have a very wide energy range originating in the disk from small to large radial positions (where kT is low).

Thus the spectrum of the Comptonized spectrum extends from below 0.1 keV to more than 40 keV .

Spectral fitting

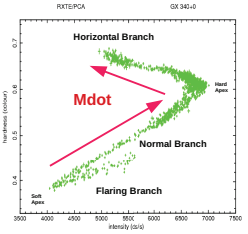
incorporating this provides a straightforward and convincing physical explanation of the Atoll sources ($L < 10^{38}$ erg s^{-1}) [ref. 1] and the Z-track sources ($L > 10^{38}$ erg s^{-1}) [ref. 5]

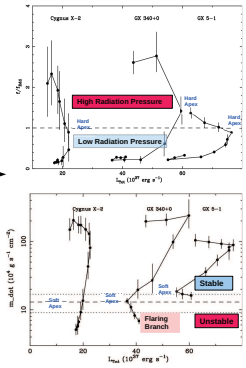
Physical description of LMXB

Accretion theory is **not sufficient**

Nuclear Burning Theory + Radiation Pressure **must be added**

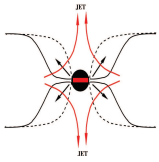
Nature of the Z-track sources





As the sources climbs the Normal Branch, the flux *f* emitted per unit area of the neutron star increases to the Eddington value f_{Edd} at the Hard Apex eventually becoming 2 – 3 times super-Eddington.

i.e. the radiation pressure becomes very strong



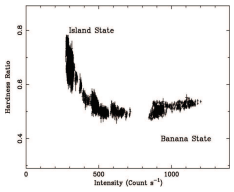
JET LAUNCHED

The mass accretion rate per unit area of the neutron star crosses the critical value $mdot_{ST} = 1.10^5$ g cm^{-2} s^{-1} close to the Soft Apex.

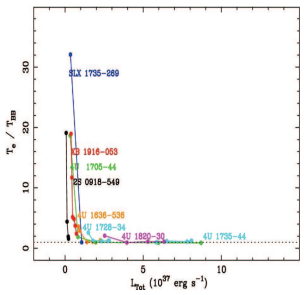
According to well-established theory of nuclear burning of accreted matter on surface of neutron star [ref. 4], below $mdot_{ST}$ burning becomes unstable – hence the Flaring Branch.

FLARING BEGINS

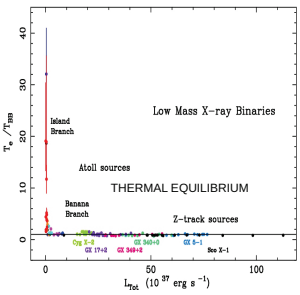
Nature of the Atoll sources



Atoll sources: RXTE + SAX



Atoll sources + Z-sources = All LMXB



The critical measurements:

the measured electron temperature T_e of the ADC

the measured NS temperature T_{NS}

and thus the ratio T_e/T_{NS}

Island State:
T_{ADC} high
Unknown heating process of ADC

Banana State:
$T_{ADC} = T_{NS}$
Basic state of Atolls

The Unified Model

ATOLL SOURCES

Island State: Hard spectrum caused by high T_{ADC}
Unknown process heats Accretion Disk Corona

Banana State: Basic State of Atolls: $T_{ADC} = T_{NS}$
THERMAL EQUILIBRIUM
Mdot increases

NO 3rd Branch in Atolls (corresponding to Flaring Branch)

as Mdot << $Mdot_{ST}$

Z-TRACK SOURCES **THERMAL EQUILIBRIUM**

Normal Branch: Same as Banana State
Mdot increases
At Hard Apex T_{NS} high

Radiation pressure of NS high
Jet launched

NO Island State in Z-track sources

as T_{ADC} is always low

Horizontal Branch: Recovery after Jet
Mdot decreases

Flaring Branch: Unstable Nuclear Burning

References

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4. Bildsten L., 1998, in Proc NATO ASIC 515
5. Bałucińska-Church, M., Gibiec A., Jackson N. K. & Church M. J., 2010, A&A, 512A, 9B