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Letter to the Editor

Mass transfer via wind-RLOF in Supergiant X-ray binaries

A possible mechanism for Ultraluminous X-ray sources

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ABSTRACT

Here, we identify the parameters required for a SgXB to be the stage of a mass transfer suitable for ULX accretion levels. The key-parameter? Ratio of wind speeds : wind-RLOF.

Key words. XXX accretion, accretion discs – X-rays: binaries – stars: neutron, supergiants, winds, outflows – methods: numerical

1. Introduction

What is it? Webb. Review by Kaaret2017. Draw the line at 1E39erg/s (Eddington limit for a 10 solar masses BH). Plurality of origins and at this point, we can not discard that some might be IMBH. Although another scenario is investigated in this letter.

Regardless of the mechanism which explains the super-Eddington accretion rates in the immediate vicinity of the accretor, which source of matter? Likely binary systems (natural extension of the HMXB LX distribution) where a donor star plays the role of a reservoir tapped by the orbiting compact object. In P13 for instance, high mass star + NS. In M101, the spectrum is suggestive of a WR star and the accretor might be a BH (Liu2013).

X-ray binaries have lower luminosities though. Neither RLOF nor wind BHL can reach these levels. RLOF, LMXB, limited by the transverse section of the channel @ L1 while fast winds (HMXB) mean low capture cross-sections. The first is essentially limited by the small sound speed compared to the orbital speed while the second is limited by the large wind speed with respect to the orbital speed. => wind-RLOF configuration leading to enhanced accretion, best of both worlds when the stellar mass loss rate is large. **?** suggested that above a mass ratio unity, unstable RLOF mass transfer occurs on a thermal time scale and lead to high mass accretion rate onto the compact companion. However, **?** recently found that RLOF mass transfer can be stable for large q, up to 7.5. Not high enough though to match the mass ratio in P13 where the stellar mass is at least 10 times larger than the mass of the accreting NS.

2. Line-driven wind acceleration in SgXB

2.1. Empirical proxy to deduce acceleration from beta-laws

2.2. The equation of motion

3. Mass transferred via wind-RLOF

We differentiate 3 mass rates : $\dot{M}$, $\dot{M}_{\star}$ and $\dot{M}_{acc}$

in the sense of “entering the effective region of accretion" (either Roche lobe of the accretor or set by the accretion radius). Upper limit. For fast wind, effective cross-section set by accretion radius which decreases quickly and much below the radius of the Roche lobe of the accretor when the speed of the wind entering the Roche lobe gets larger than the orbital speed.

3.1. Fraction of stellar wind available for accretion

Mapping of the stellar surface feeding the accretor Roche lobe : contribution of the high latitudes (Fig.2 : the Mollweide projection)

% of stellar mass loss rate entering the accretor Roche lobe (Fig.3) 1st row is M101? Or Cyg X-1? 2nd row is P13?

A comparison to BHL formula (Fig.4)

3.2. Accretion luminosity

Absolute values, how realistic?

4. Discussion and conclusions

BHL

RLOF

AGB and RSG donor stars have unknown wind launching process, no report of beta-law velocity profile but low terminal

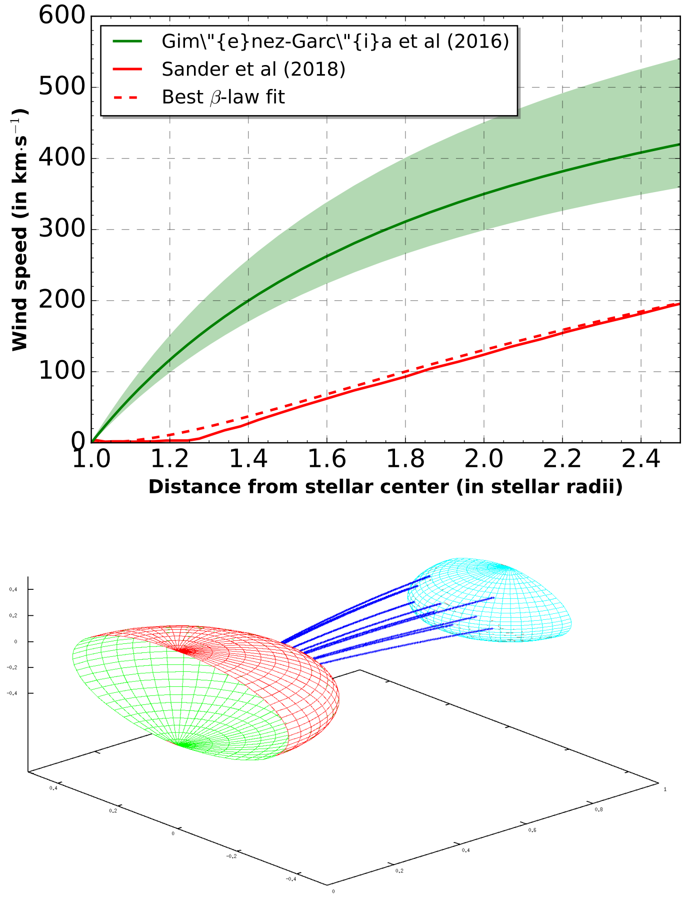

Fig. 1: (upper panel) Wind velocity profiles of a representative B0.5 Ib supergiant star, HD 77581 (the donor star in Vela X-1 **??**). The green solid line is the β-velocity profile deduced by **?** from observations, while the green shaded region shows the uncertainties on the terminal wind speed. **?** computed the hydrodynamic atmosphere solution for the wind stratification (red solid line), here fitted by a β-velocity profile (dashed red line). (lower panel) Illustration of the integration of the streamlines (orange) from the stellar surface (blue) to the Roche lobe of the accretor (transparent green).

Table 1: Scaled X-ray luminosity of a classic SgXB (Vela X-1) and of a ULX (P13) assuming a similar fraction of the wind captured of $\sim 5\%$ obtained with $q = 15$, $f = 95\%$, $\beta = 2$ and $\eta = 2$.

	Vela X-1	P13
$\dot{M}/\dot{M}_{\star}$	$\sim 5\%$	
$\dot{M}_{acc}/\dot{M}$	4%	40%
$\zeta = L_X/\dot{M}_{acc}c^2$	10%	10%
$\dot{M}_{\star}$	$5{\cdot}10^{-7}$M$_{\odot}{\cdot}$yr^{-1}	10^{-4}M$_{\odot}{\cdot}$yr^{-1}
L_X	$5{\cdot}10^{36}$erg${\cdot}$s^{-1}	10^{40}erg${\cdot}$s^{-1}

speeds and large mass loss rates => could also work for them (Heida).

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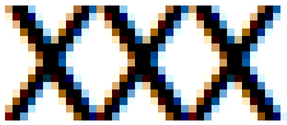

Fig. 3: XXX

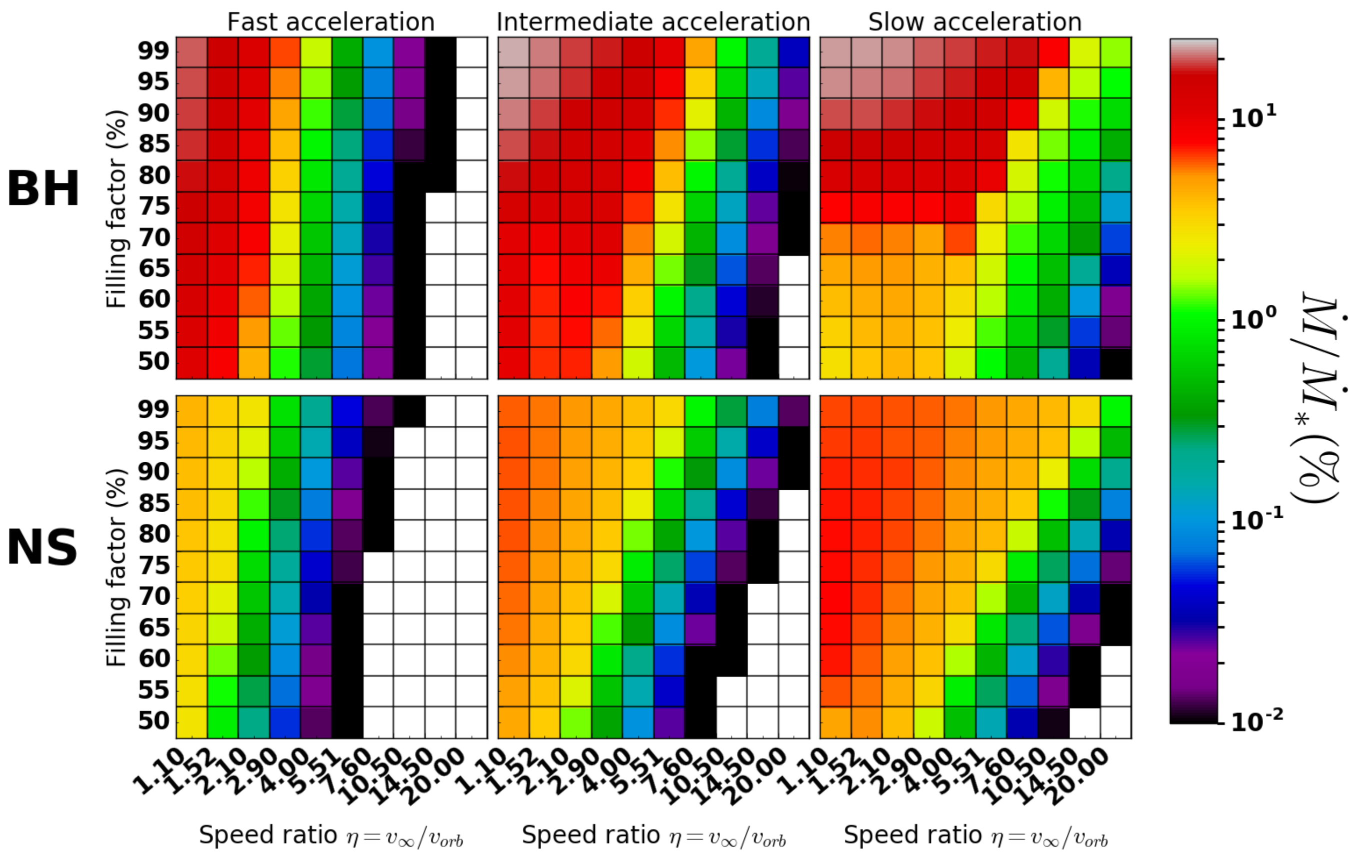

Fig. 2: Logarithmic color maps of the fraction of stellar wind captured by the accretor as a function of the stellar filling factor and of the ratio of the terminal wind speed by the orbital speed. From left to right, the β exponent is 1, 2 and 3, which means a more progressive acceleration up to the terminal speed. The first (resp. second) row stands for a mass ratio of 2 (resp. 15) which means, for a fixed 20 solar-masses supergiant donor, an accreting 10 solar-masses BH (resp. a 1.3 solar-masses NS).