Colliding winds in evolved massive star systems

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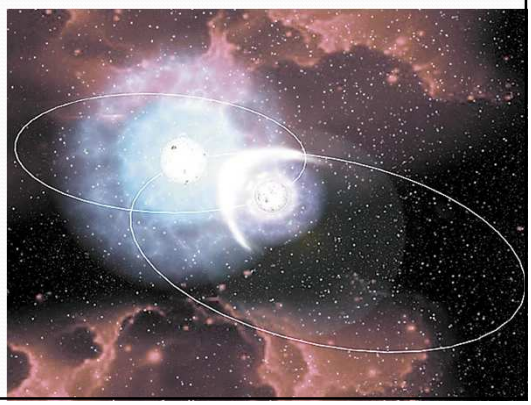
Colliding winds

- Two massive stars
  = two supersonic winds
  $\Rightarrow$ collision
- Shocked plasma seen from radio to γ-rays
  - X-rays : since first obs. of massive stars (Einstein, ROSAT)...



Colliding winds

Phase-locked variability !

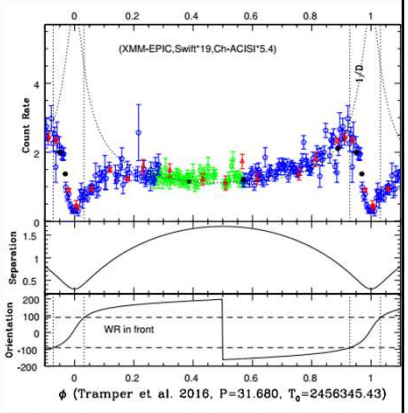
- Absorption (line-of-sight crossing one wind then the other or @periastron), esp. in asymmetric systems
- Emission, because of changing separation in eccentric systems

For a full review, see Rauw & Nazé (2016, ASR, 58, 761, arxiv:1509.06480)

WR21a
HD166734
HD5980

WR21a

- WN5+O3, P=31.7d, e=0.694
- XMM, Swift, Chandra data
- Lightcurve :
  - ϕ=0.2-0.7: ~cst
  - ϕ=0.7-0.9: ~ 1/D ⇒ adiabatic!
  - Then sharp decrease (minimum @ conjunction for soft X, @ periastron for hard X)
  - Then shallower increase

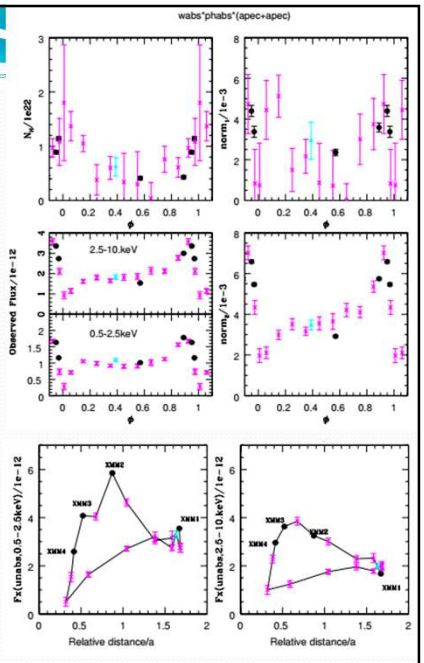


Gosset & Nazé 2016

WR21a

- Spectra :
  - kT=0.8 & 3 keV, stable
  - Nh increase towards conj.
  - EMs vary !
- Collision:
  - Should be radiative but as in Zhekov (2012) : adiabatic !
  - Decrease:
    - not an eclipse : none in UV+ event too long + no γVel effect @ other conj. + M in optical orbital solution
    - absorption : Mdot (WR) revised BUT not sufficient + event too long

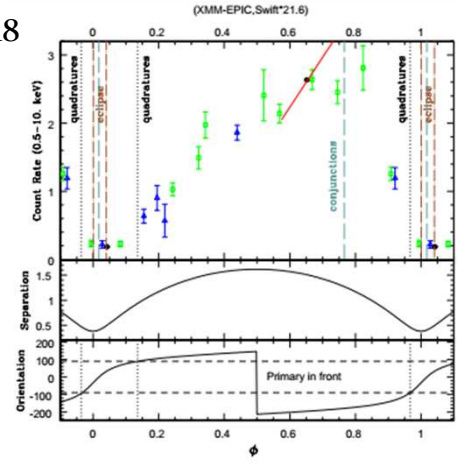
  ⇒ shock disruption BUT no softening...



Gosset & Nazé 2016

HD166734

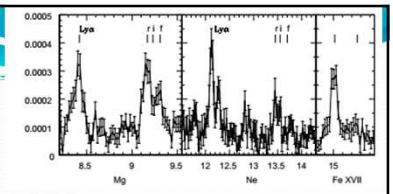
- O7.5If+O9I(f), P=34.5d, e=0.618 similar to WR21a but with (Mdot v_{inf}) ratio twice smaller
- XMM & Swift data
- Lightcurve :
  - Deep and long minimum @ periastron (exceptional!), X slightly softer (XMM) NOT an eclipse !
  - Steep decrease before, shallower increase after, quasi flattening for ϕ > 0.5
  - Steeper increase @ ϕ=0.65 NOT @ conj. or after !

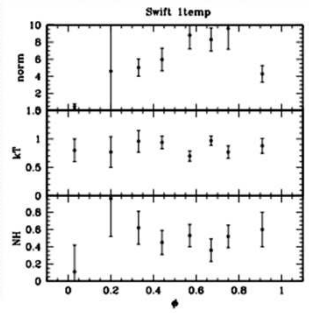


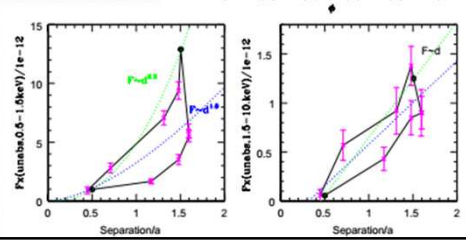
Nazé et al., 2017, in press

HD166734

- Spectra :
  - X-ray lines @max flux :
    - No significant shift
    - Width ~v_{inf}
    - (f+i)/r and He-to-H ratio : same kT
    - f strong in He triplets !
  - Global fitting :
    - kT : ~cst
    - Absorption : ~cst
    - EMs vary !
      Log(Lx/Lbol)~-7 @ min !
      Fx ∝ d^2 or d !



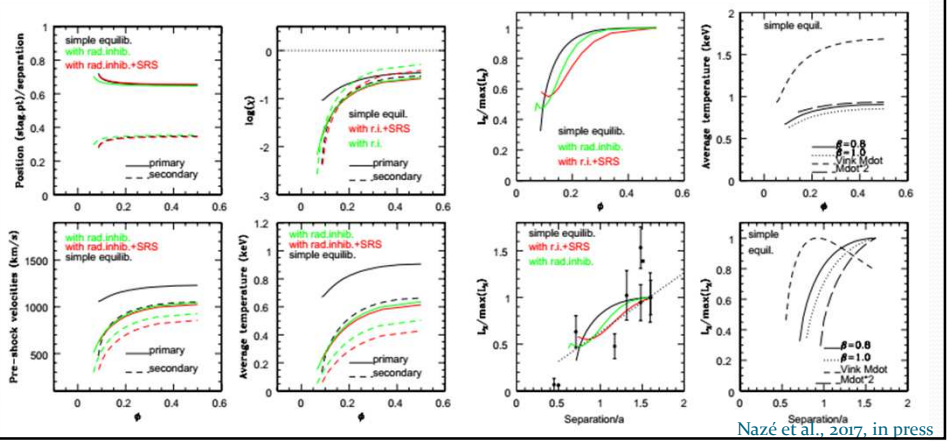




Nazé et al., 2017, in press

HD166734

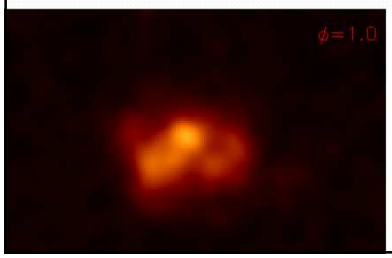
- Stellar param. known ⇒ model @ stagnation point :
  - Always radiative, Fx trend OK, but kT too variable

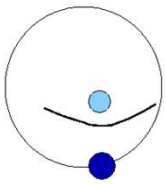


Nazé et al., 2017, in press

HD5980

- Multiple system in SMC
  - Star A= WR/LBV (eruption in 1993-4)
  - Star B=WR, P=19.3d, e=0.27, eclipses !
  - Star C=O, P=96d (around A+B?)
- Colliding winds !



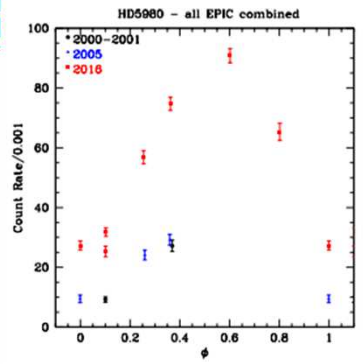


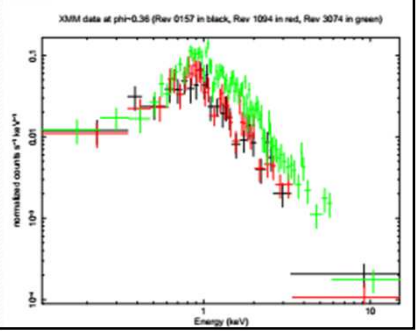
Star A back to normal...

Nazé et al., 2017, in prep

HD5980

- XMM, Chandra data : 2000, 2001, 2005, 2016
- Lightcurve :
  - Same shape
  - Flux * 2.5 + hardening !
- Spectra :
  - kT min and Nh max @apastron
  - Nh larger in 2016

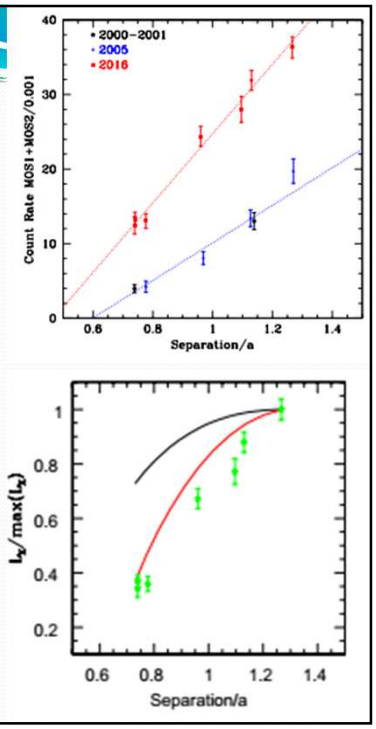




Nazé et al., 2017, in prep

HD5980

- Brightening : not a pedestal so not circumstellar, not coherent with C orbit
- Mdot(A) x 2 and v_{inf}(A) ↓ by 50% ⇒ Mdot v_{inf}^2↓ by 50%, Mdot v_{inf} ratio /2, Mdot/v_{inf} / 3.6 !
- Model of collision in A+B
  - No collapse/disruption
  - Always radiative
  - 2000-2005 similar, hardening in recent years (kT!)
  - Larger kT @ apastron
  - Emitting region not much larger



Nazé et al., 2017, in prep

The way forward

- Improving surveys: filling the parameter space
- Study of extragalactic sources as winds = f(Z)
- Monitoring of line *profiles*

IFU
ATHENA X-ray Integral Field Unit