STELLAR WIND IMPACT ON NON-THERMAL PROCESSES IN GAMMA-RAY BINARIES

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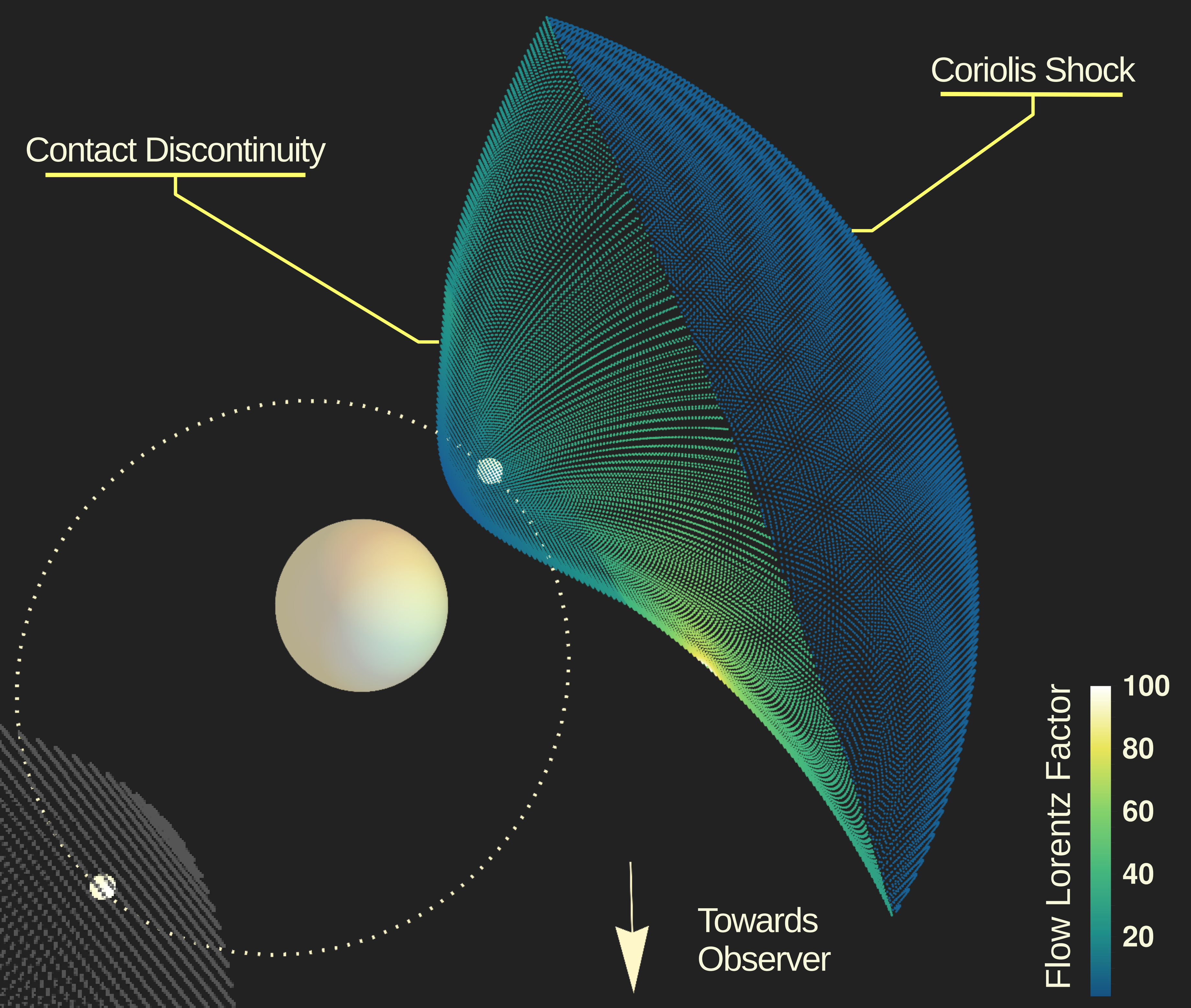
I. ROTATION-POWERED BINARIES

Gamma-ray binaries are the pairing of an energetic pulsar and a massive star. Their emission, peaking at MeVs and extending up to TeVs, is intricately tied to the orbital motion. In the wind-driven scenario, non-thermal emission is fueled by the pulsar's spin-down. The pulsar wind interacts with the wind from the companion star forming a double bow shock with a contact discontinuity (Cantó et al. 1996). On large scales, orbital motion causes the pulsar wind to progressively “bend”. The asymmetric wind–wind interaction produces a second shock at the Coriolis turnover location (Bosch-Ramon & Barkov 2011; Zabalza et al. 2013).



II. MODELLING THE EMITTING REGION

The contact discontinuity and Coriolis shock are the primary locations for particle acceleration and non-thermal emission. The emitting region largely scales with the orbital phase (consistent with hydrodynamic simulations; Bosch-Ramon et al. 2015; Kissmann et al. 2023) for eccentric orbits, so the processes related to the two-wind interaction proceed under different physical conditions at different orbital phases. Our semi-analytical modelling accounts for angular effects related to orbit-induced bending and relativistic effects related to the acceleration of the shocked flow.

III. RADIATIVE REGIMES & EMISSION

The reacceleration of the flow also means that we need to be aware of the dominant cooling processes at each region. Close to the apex the emitting region is radiative, but downstream of the shock we may deal with adiabatic cooling. Thus, the emission is modeled by a leptonic multi-zone model considering synchrotron and inverse Compton, γ-ray absorption, and particle escape. The adopted particle distribution is a simple power law with an exponential cutoff.

Adopted Parameters	
Pulsar spin-down power	$L_{pw}=10^{37} erg s^{-1}$
Stellar wind mass-loss rate	$\dot{M}=1\times10^{-7} M_{\odot} yr^{-1}$
Power-law index	$p=1.2$
Minimum electron energy	$E_{min}=1$ GeV
Magnetization (wrt shocked pulsar wind pressure)	$\eta_B=0.3$
Acceleration factor	$\eta_{acc}=0.5$

APPLICATION TO LS 5039

(Dubus et al. 2015; Molina & Bosch-Ramon 2020; Huber et al. 2021; Yoneda et al. 2021)

+ X-rays may be a product of a broken power law with a hard high-energy component.
+ The computed MeV band shows behavior consistent with observations but fluxes do not reach the data.
+ A lower-energy component dominated by inverse Compton losses and possibly related to the unshocked pulsar wind electron energy distribution is needed to explain the GeV.
+ TeV emission originates from the Coriolis shock where γγ absorption is less relevant.

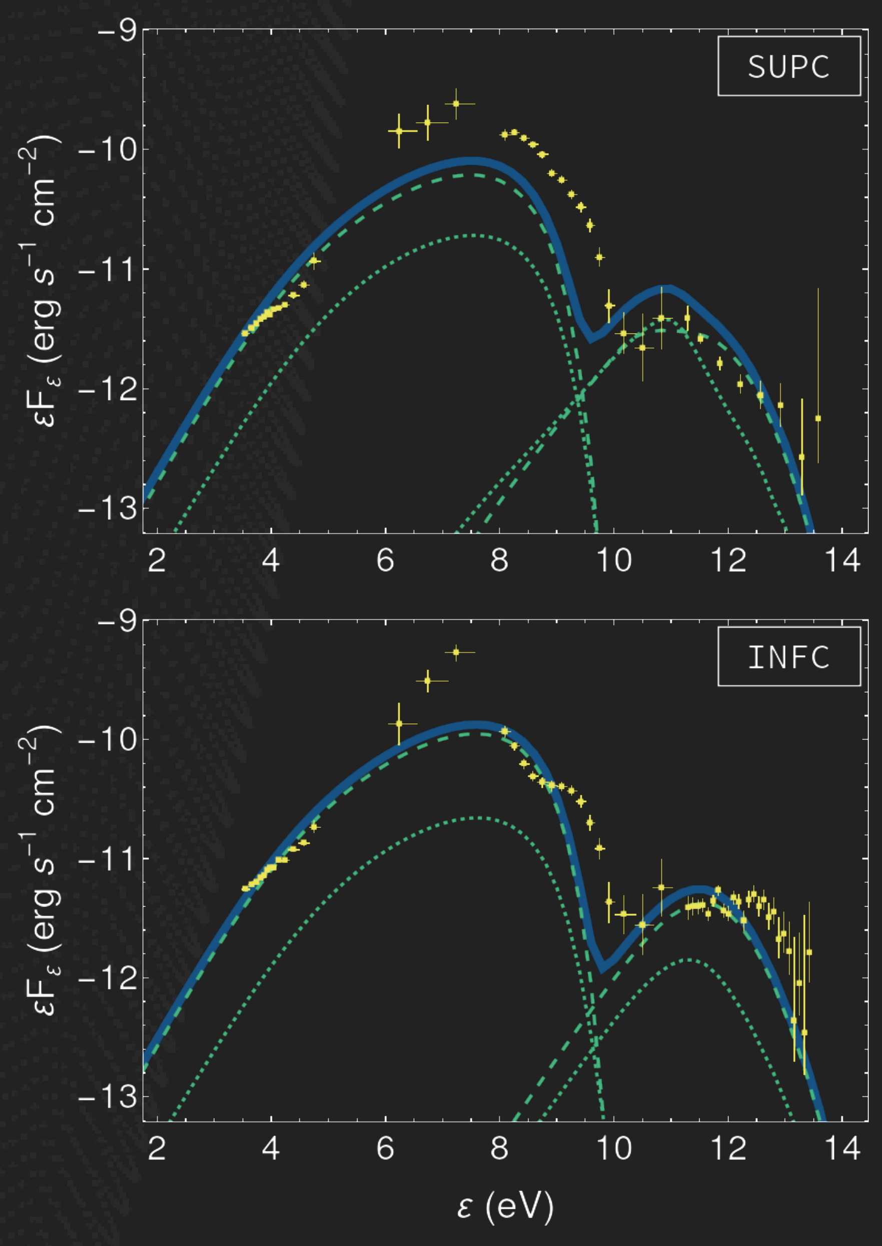


Fig. 1. Modeled (blue line) and observed (yellow points) averaged spectra at SUPC and INFC. The dashed and dotted lines are the contact discontinuity and Coriolis shock contributions, respectively.

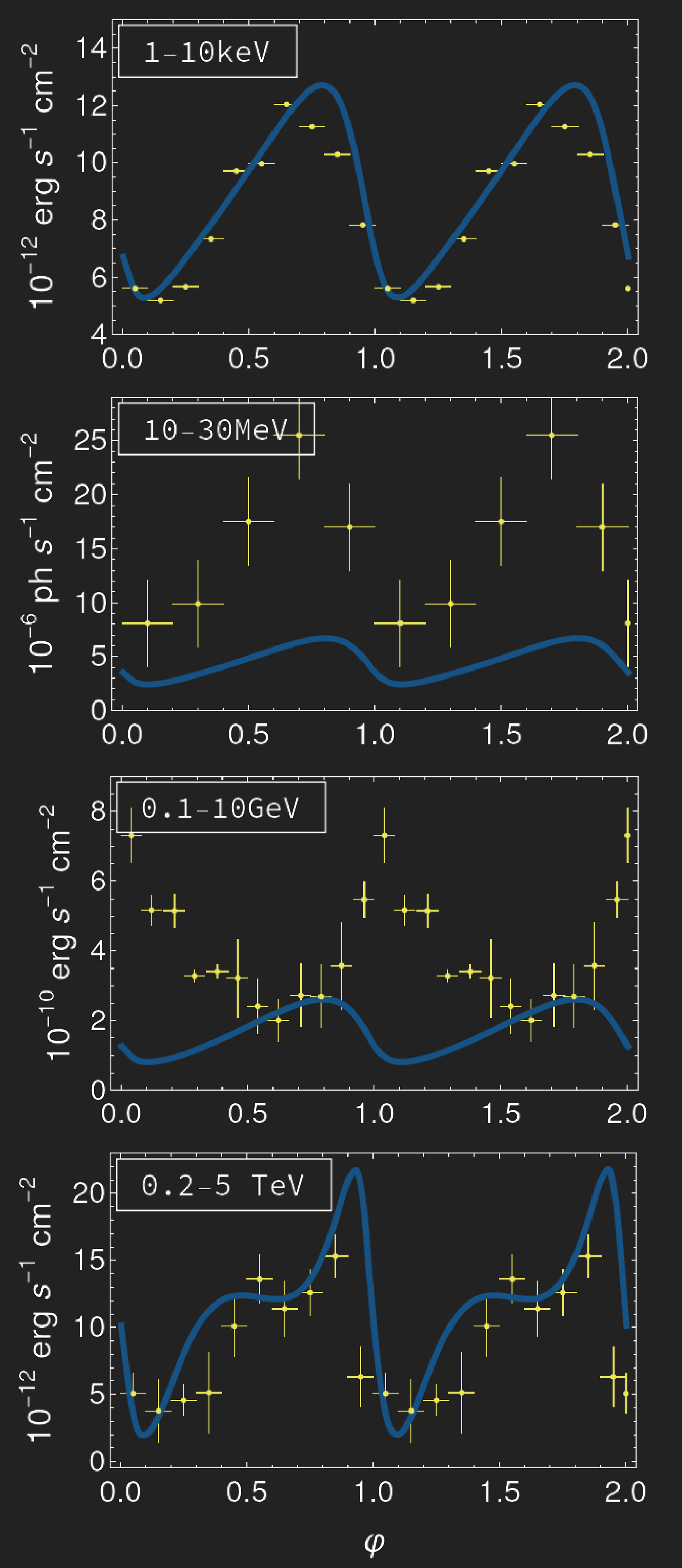


Fig. 2. Modeled (blue line) and observed (yellow points) light curves for X-ray (*Suzaku*), MeV (COMPTEL), GeV (*Fermi*/LAT), and TeV (H.E.S.S.) bands.

Bosch-Ramon & Barkov 2011, A&A, 535, A20; Bosch-Ramon et al. 2015, A&A, 577, A89; Cantó et al. 1996, ApJ, 469, 729–733; Dubus et al. 2015, A&A, 581, A27; Huber et al. 2021, A&A, 649, A71; Kissmann et al. 2023, A&A, 677, A5; Molina & Bosch-Ramon 2020, A&A 641, A84; Yoneda et al. 2021, ApJ, 917, 2; Zabalza et al. 2013, A&A, 551, A17