A Parameterized YSO Accretion Disk Model with Increasing Accretion Rate: Predicted Outburst Lightcurves

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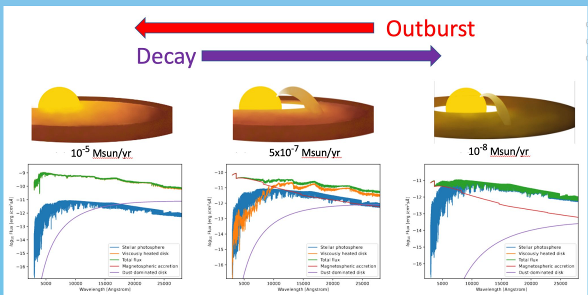
Introduction and Summary

We use a parametric model that couples the stellar photospheric emission,magnetospheric accretion shocks, an irradiated dust disk, and a viscously heated gas disk. We adopt time-dependent accretion rate profiles that mimic the observed morphologies of FU Ori outburst light curves, and we use the accretion model infrastructure to simulate multi-band light curves, as well as color curves. The model enables us to study how different components dominate the flux in each band over the course of an outburst, providing insight into star-magnetosphere-disk interactions throughout the outburst cycle. We find that throughout an accretion outburst, red optical and near-infrared lightcurves generally follow the same or very similar form as the input accretion profile, being sensitive to heating in the accretion shocks and inner gas disk, while mid-infrared lightcurves are more responsive to the location and heating of the innermost dust disk.



(a) High Accretion (b) Intermediate Accretion (c) Low Accretion

Forward-Modeling Pipeline

Part II (Das et al.)

Emission components computed separately, summed, convolved with filter bandpasses → multi-band lightcurves

Stellar Photosphere

BT-Settl atmosphere at T_star; photosphere dominates in the UV and optical at low Ṁ.

Magnetospheric Accretion Hotspot

$H+H^-$ slab model → T_hotspot and n_e derived from Ṁ and increase drives u-band brightening.

Active/Viscous Gas Disk

Modified Shakura-Sunyaev viscous disk → T_acc(r); increasing Ṁ drives optical/NIR brightening.

Passively Heated Dust Disk

Chiang & Goldreich irradiated disk → T_dust(r); increasing Ṁ drives MIR/NIR brightening.

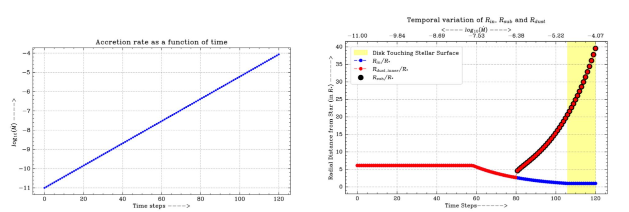
For an adopted accretion profile Ṁ(t), **at each time step** compute the temperatures, density, velocity, dust/gas inner radii.

Test Case: Linear Accretion

We first explore the implications of a simple linear rise in the accretion rate on the magnetospheric and disk gas and dust heating.

Example of Linear Accretion Rate Increase

Part II (Das et al.)



Note that details will depend on the stellar parameters (R, M, P_rot).

Generally we find four regimes as Ṁ increases:

[0–40] Low state: Rin = Rco-rotation; T_hotspot < T_star; photosphere and dust dominate the SED.

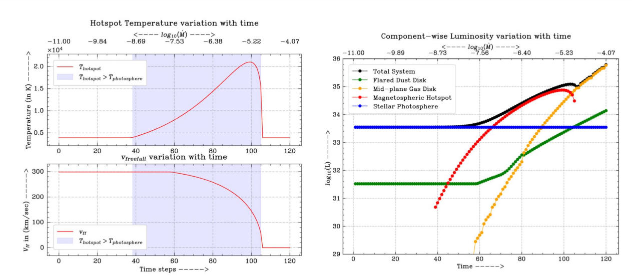
[40–60] Magnetospheric brightening: T_hotspot rapidly increases.

[60–100] Inner disk brightening: R_trunc decreases; R_sub expands outward; overall rise in T(r) and increasing flux from gas disk.

[100–120] High state: disk touches stellar surface; poloidal accretion off; gas disk dominates SED.

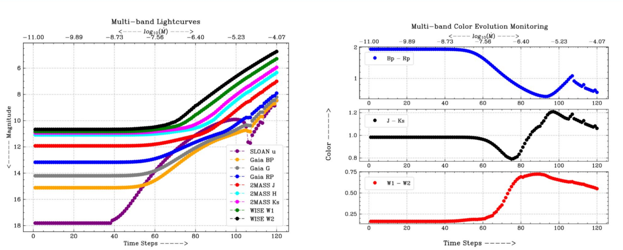
Example of Linear Accretion Rate Increase

Part II (Das et al.)



Example of Linear Accretion Rate Increase

Part II (Das et al.)



Lightcurves appear different at different wavelengths as Ṁ increases:

UV rises first (hotspot heating) → MIR next (dust sublimation front expansion) → optical/NIR last (gas disk viscous heating)

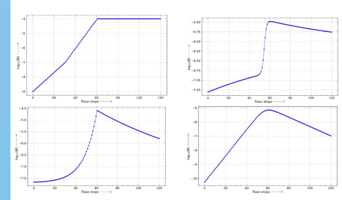
Colors become bluer during accretion rate increase, though mid-infrared can become red before becoming bluer at high M(t).

Application to Other Accretion Profiles

We adopt functional fits to the lightcurves of several bona fide FU Ori sources as their accretion profile, and Apply our infrastructure to produce lightcurves.

Mimicking FU Ori Accretion Profiles

Part II (Das et al.)



Different assumed accretion profiles.

Peak Ṁ is from SED modelling in literature; low-state Ṁ is estimated from lightcurve amplitude.

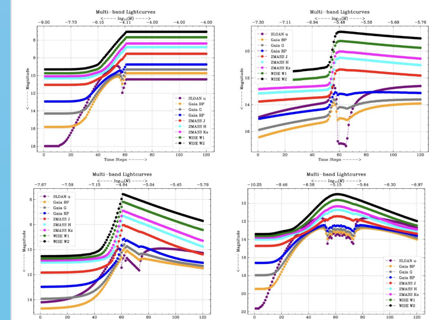
Lightcurve types modeled:

HBC 722-Like
Gradual rise → steep rise → plateau
(3-piece linear function)

V890 Aur-Like
Shallow rise → steep approach → high plateau
(tanh function)

V960 Mon-Like
Sharp rise → exponential decay
(two-sided exponential function)

Gaia 17bpi-Like
Short-lived peak → rapid decline
(logistic × Gaussian)



Lightcurves for the different assumed accretion profiles.

Results

The typical outburst behavior as *Ṁ increases is:*

- UV/u-band rises first (magnetospheric hotspot brightening),
- MIR next (expanding dust sublimation front),
-optical/NIR last (gas disk brightening).