Numerical simulations of the spreading of accreted matter on white dwarfs

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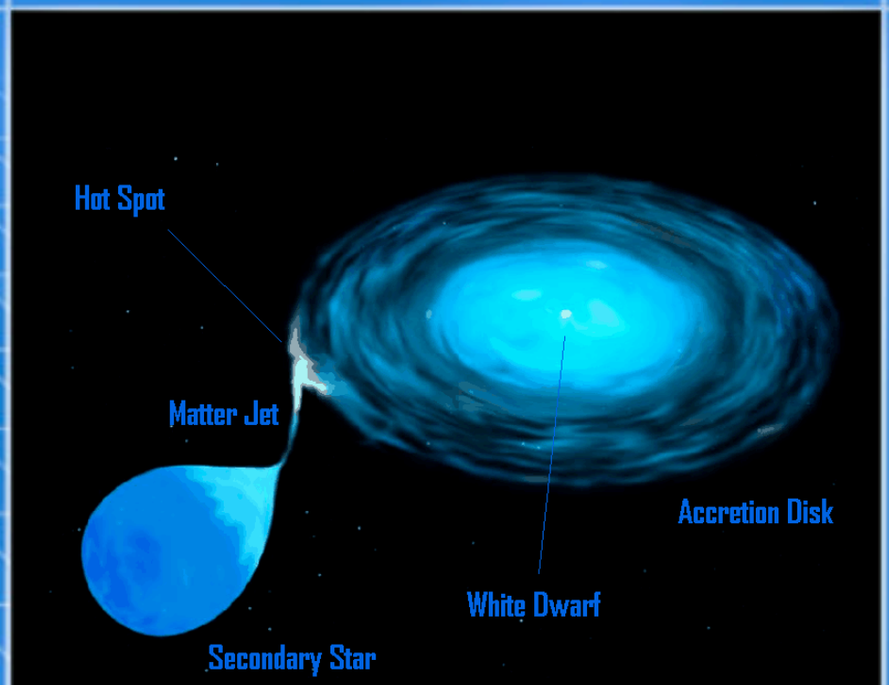
Accr. white dwarfs

- Binary star with WD & secondary main sequence star
- Roche lobe overflow
- Excess angular momentum forms accretion disk
- .. where matter drifts in and accretes..



Orbital separation: ~300000km
Orbital period: ~1-3hr
Many behaviors:
CN, DN, RN, NL,IP, Polars

Fisker et al., JINA Frontiers 2005

Accretion process

Matter transfer from "infinity" to the surface: $E = -\frac{GMm}{R}$

Rate of energy liberated with continuous transfer: $L = \frac{GM\dot{m}}{R}$

Disk matter moves in circular orbits: $mv^2/r = GMm/r^2$, $v_K(r) = \sqrt{GM/r}$

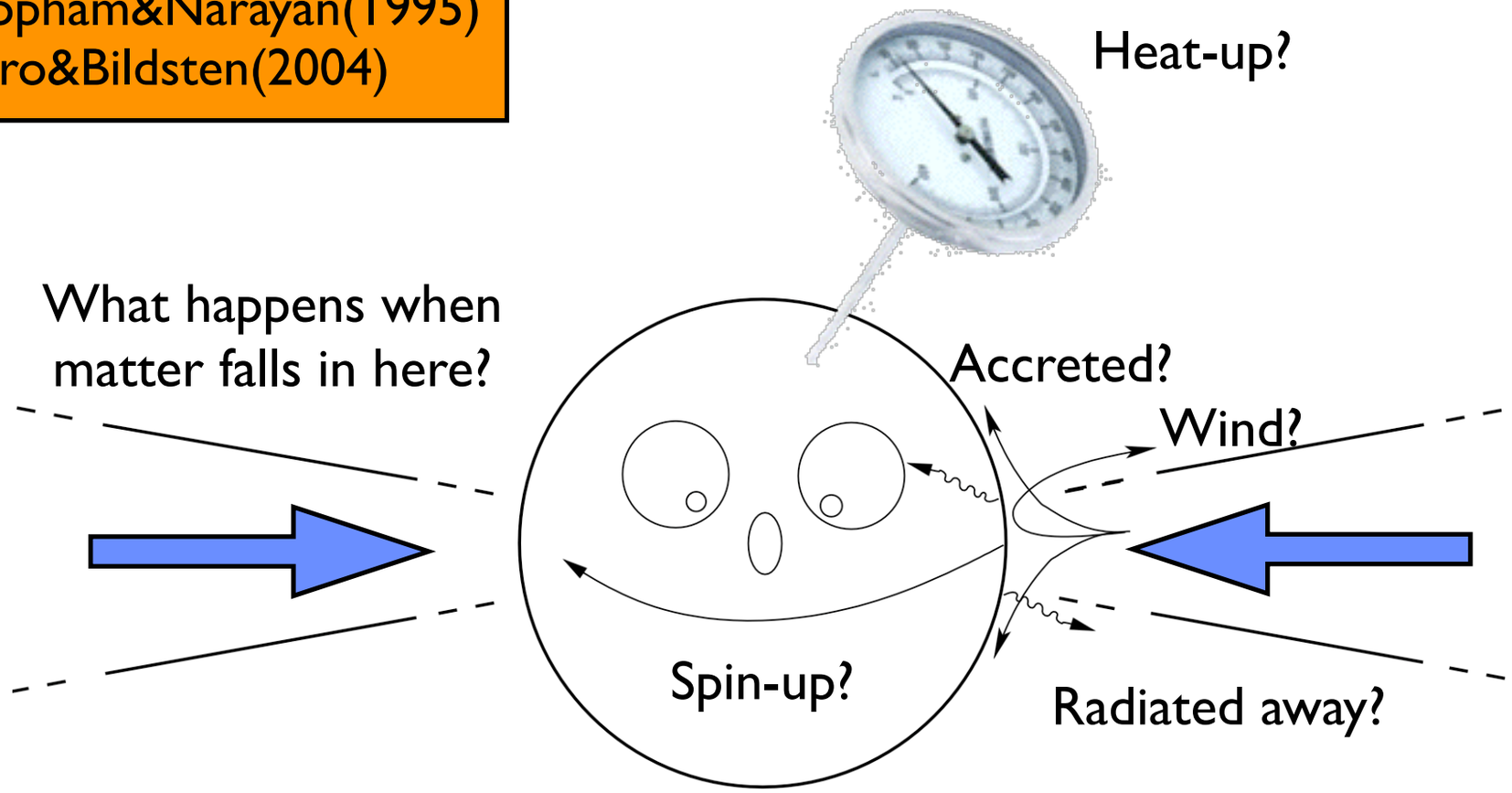
Shear forces from differential rotation heats and slows down matter which falls in...

At the surface it must decellerate fully to accrete!

$$L_{BL} = \frac{1}{2}\dot{m}(v_K^2 - v_*^2) \approx \frac{1}{2}\dot{m}v_K^2 = \frac{1}{2}\frac{GM\dot{m}}{R} = \frac{1}{2}L$$

Fisker et al., JINA Frontiers 2005

Kley(1991)
Popham&Narayan(1995)
Piro&Bildsten(2004)

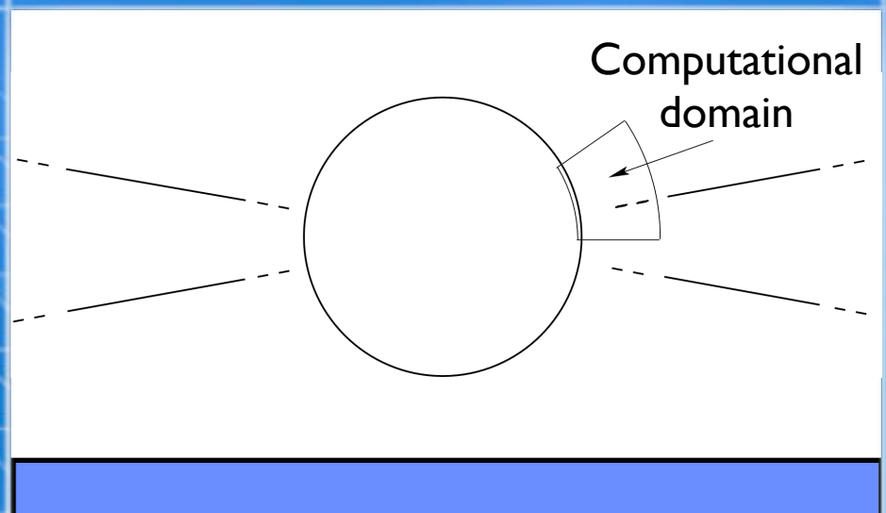


The boundary layer

Fisker et al., JINA Frontiers 2005

Our BL model

- Compressible Navier-Stokes eq.
- Ideal gas (solar)
- Shear forces are parametrized with an alpha coefficient



Several scl. heights of atm./disk
0-30 degrees
384x128x1(log)
axisymmetric

Fisker et al., JINA Frontiers 2005

Numerical Simulations

- We use the spatially and temporally second-order accurate code RIEMANN.
- We run models for 5 different shear coefficients (0.1, 0.03, 0.01, 0.005, and 0.001)

Star Trek IV
"The voyage home"

Scotty: Computer ---
Scotty: Hello? Computer...
Nichols: Just use the keyboard...
Scotty: The keyboard... how quaint.

Fisker et al., JINA Frontiers 2005

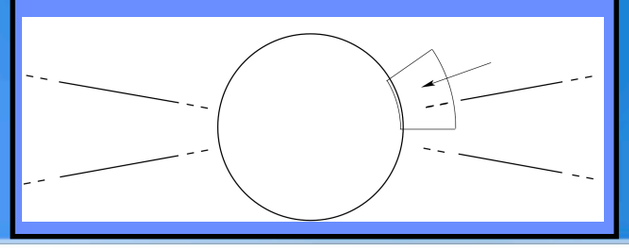
Comparison to observations

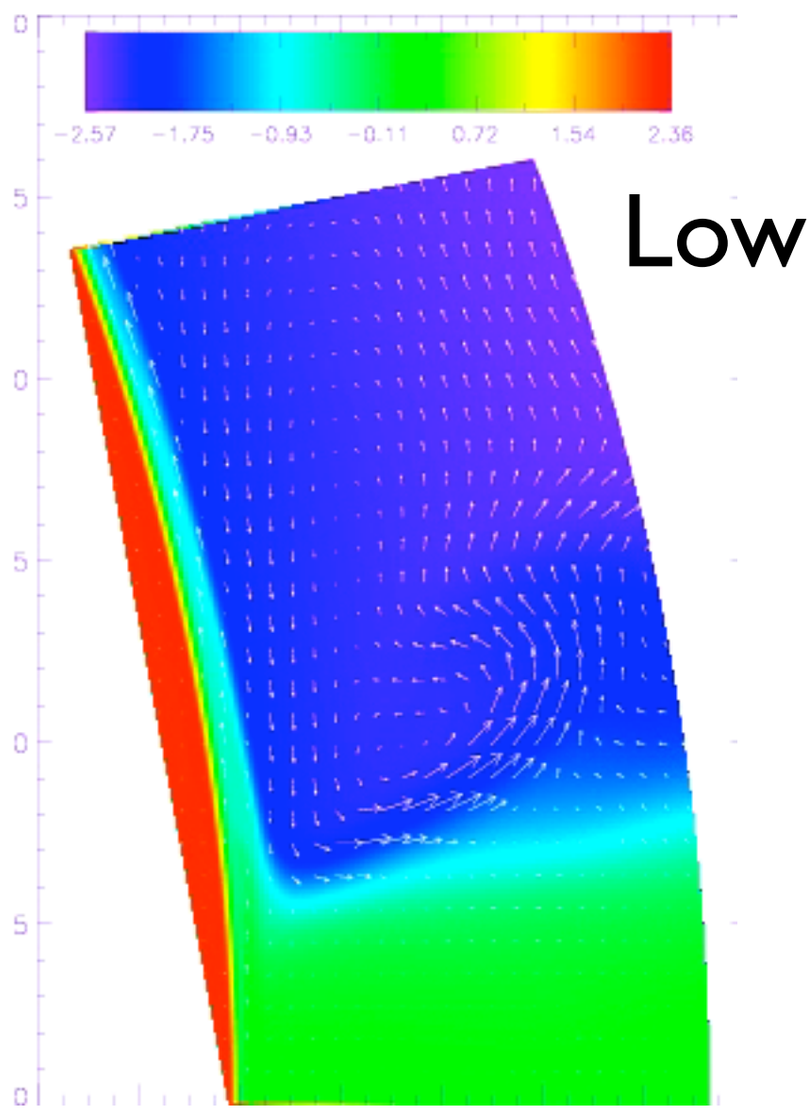
Fisker et al., JINA Frontiers 2005

Dwarf novae

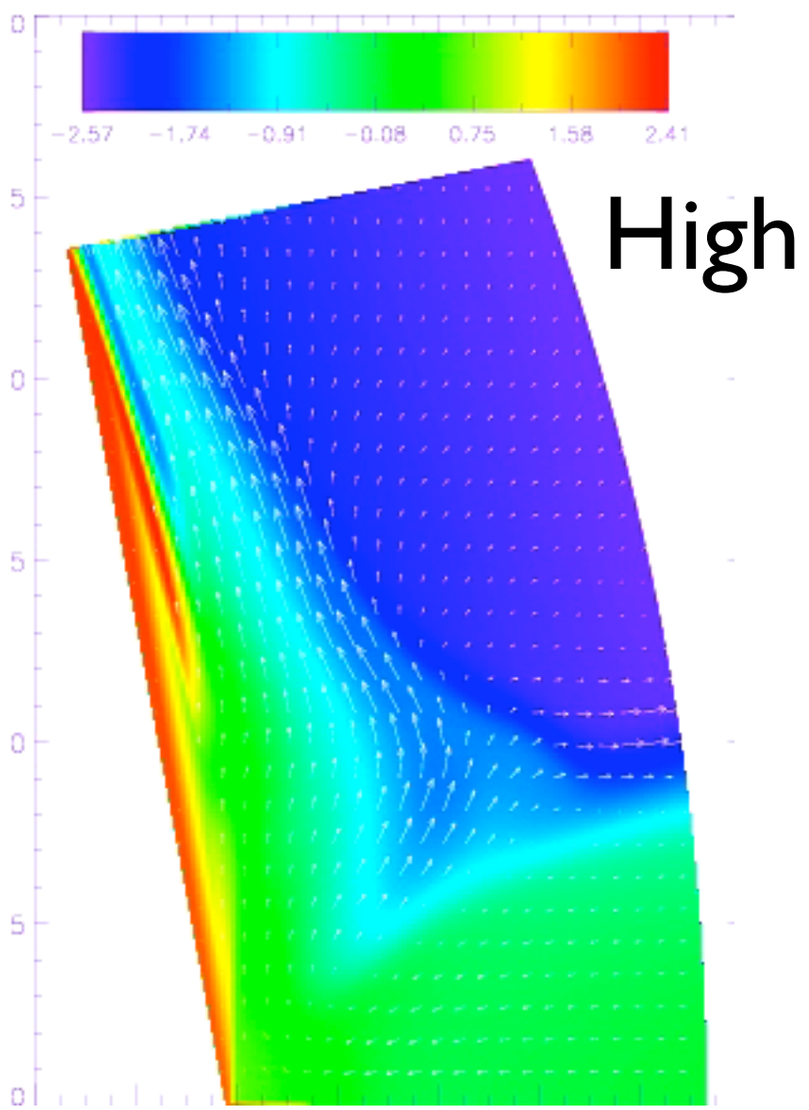
- Dwarf novae are binaries which show recurrent 2-5 mag outbursts.
- Disk instability leads to a state with high shear (and high accretion) and a state wih low shear (and low accretion).
- We want to understand the structure of the BL during those two states!

Fisker et al., JINA Frontiers 2005





Low



High

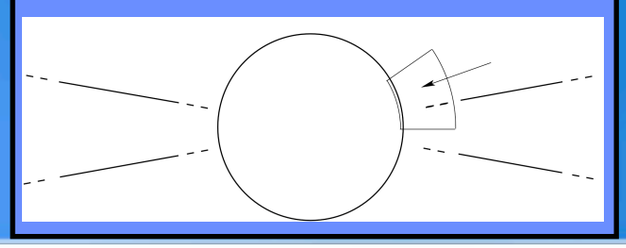
Log Density

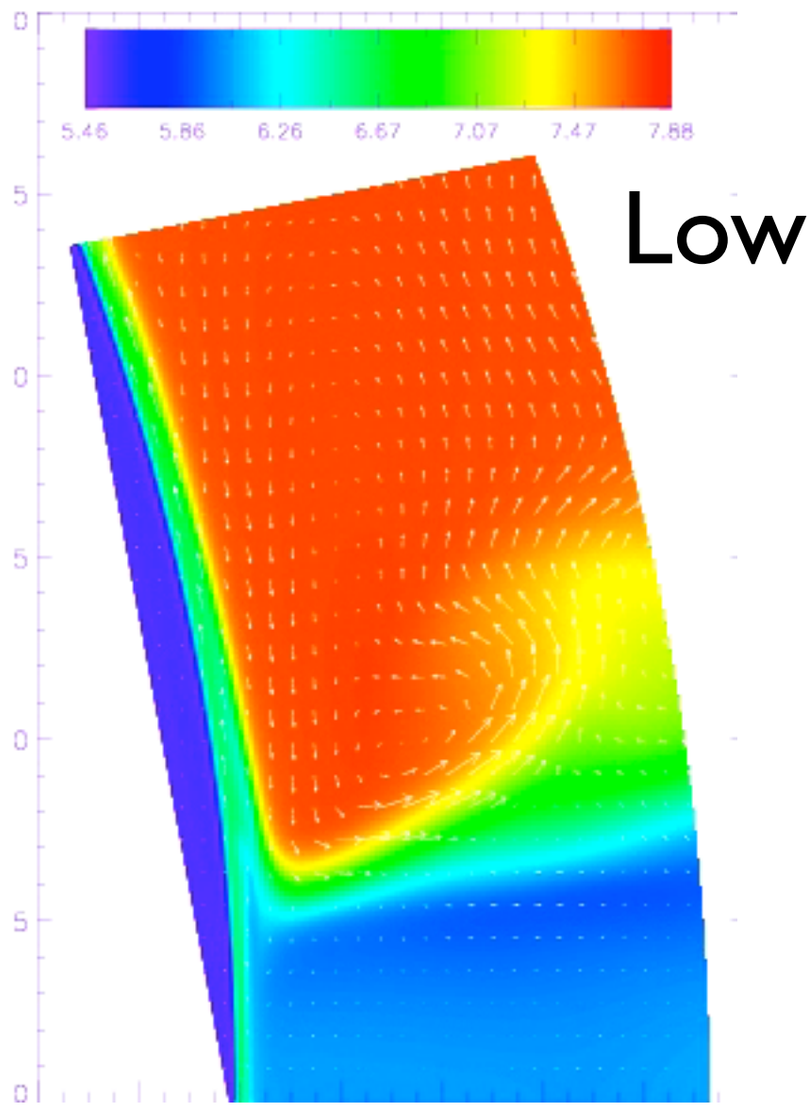
Fisker et al., JINA Frontiers 2005

U Gem Observations

- Model suggests an explanation for observations of U Geminorum during quiescense.
- Many observations has shown a small hot and slowly decaying continuum component and an optically thin line-emitting region during quiescence.

Fisker et al., JINA Frontiers 2005





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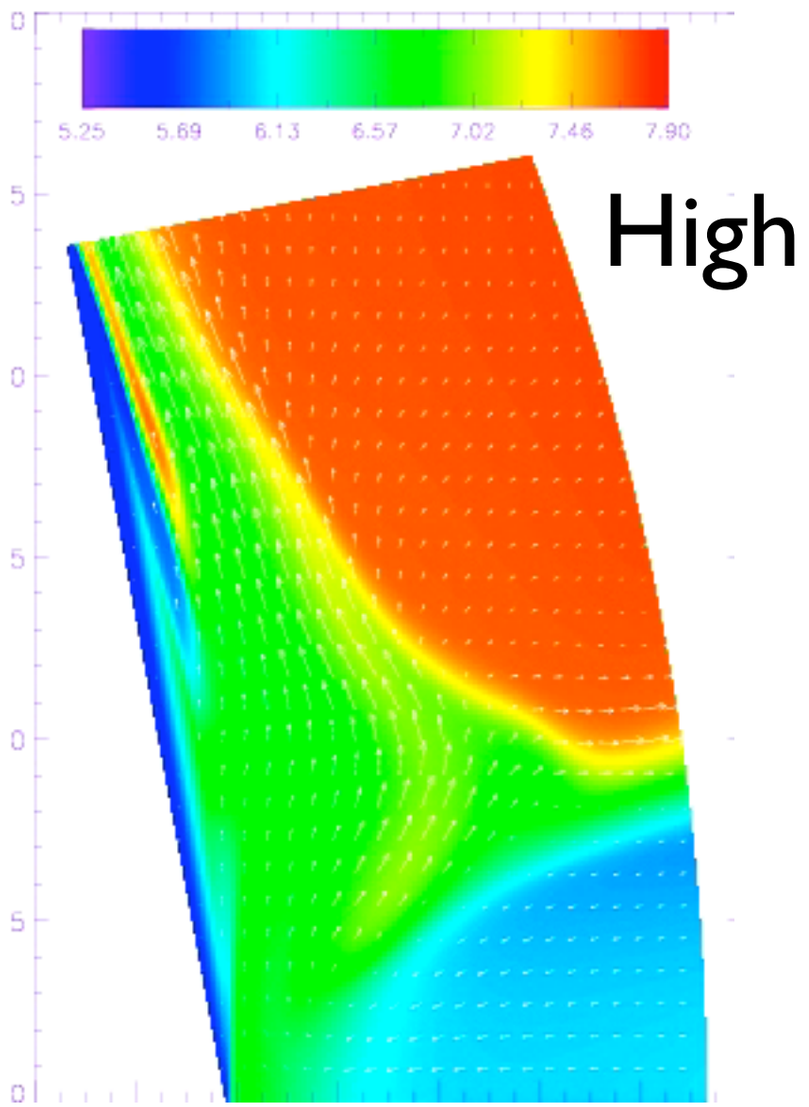

High

Log Temperature

Fisker et al., JINA Frontiers 2005

Conclusion

- We have built/are building multi-D simulations of accreting stars which have predictive powers.
- Radiative transport/spectrum, accretion composition/mixing, nuclear burning and flame propagation, MHD.
- Extends to neutron stars and protostars.

Fisker et al., JINA Frontiers 2005