Sun and stellar accretion of cool plasma

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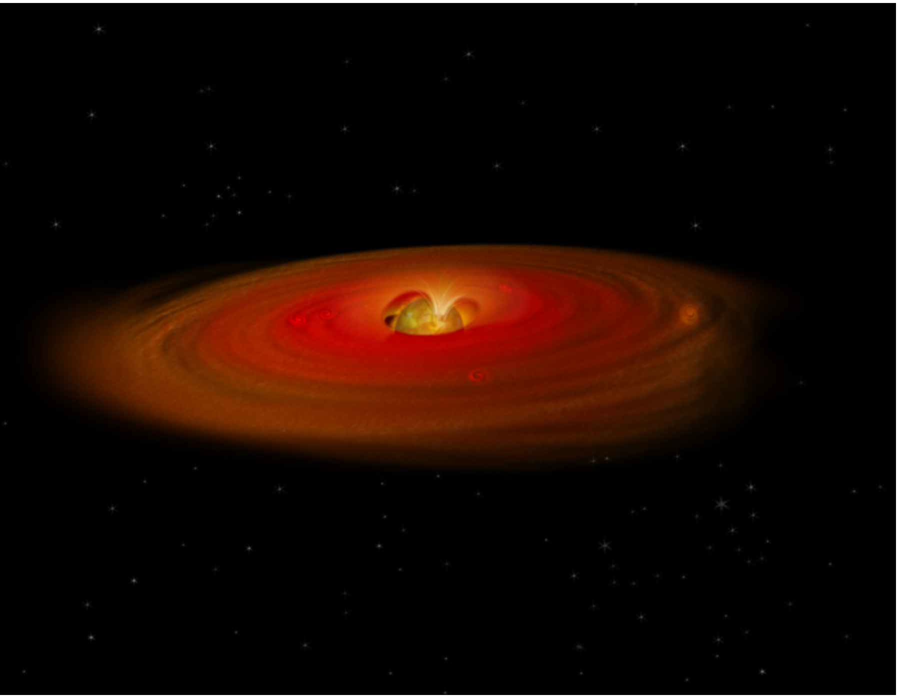
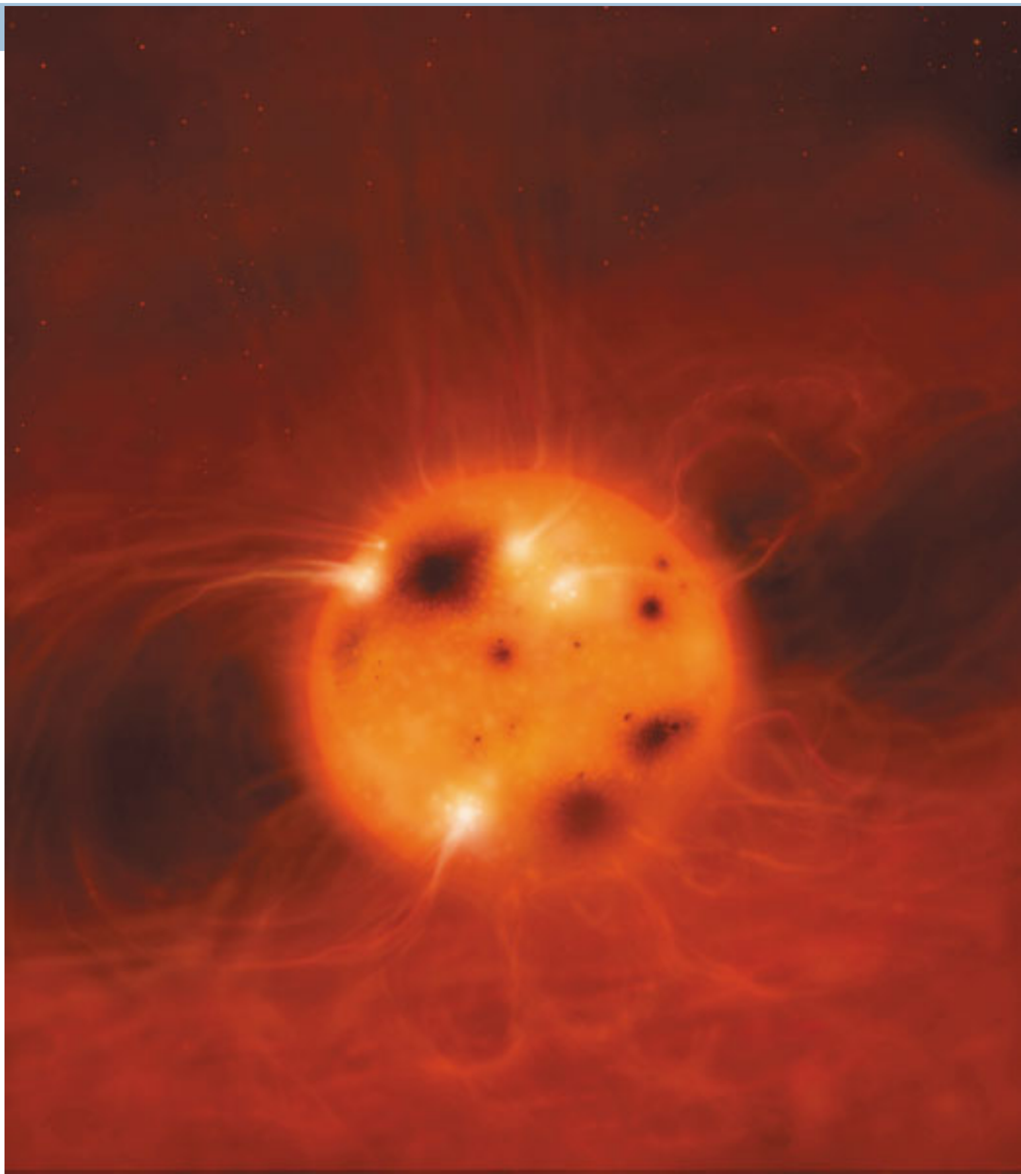
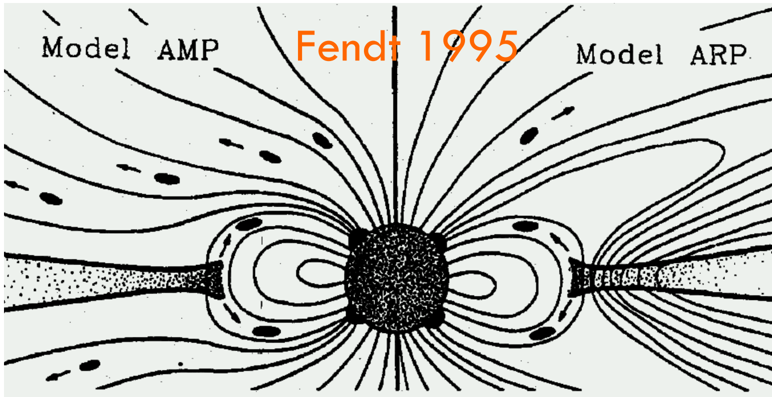
Accretion flows on young stars (T Tauri)

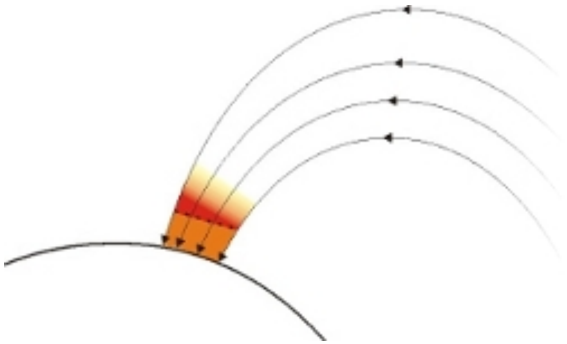




Accretion in YSO

- Disk-star: magnetic funnels (Königl 1991)
- Accretion: V»100 km/s
- Impact: IR/V/UV excess (Bertout et al. 1988, Natta et al. 2006, Herczeg & Hillenbrand 2008, Donati et al. 2008)
- +Soft X-ray excess: dense (10^{11} – 10^{13} cm^{-3}) and hot (2-4 MK) plasma (Kastner et al. 2002, Telleschi et al. 2007, Argiroffi et al. 2007)

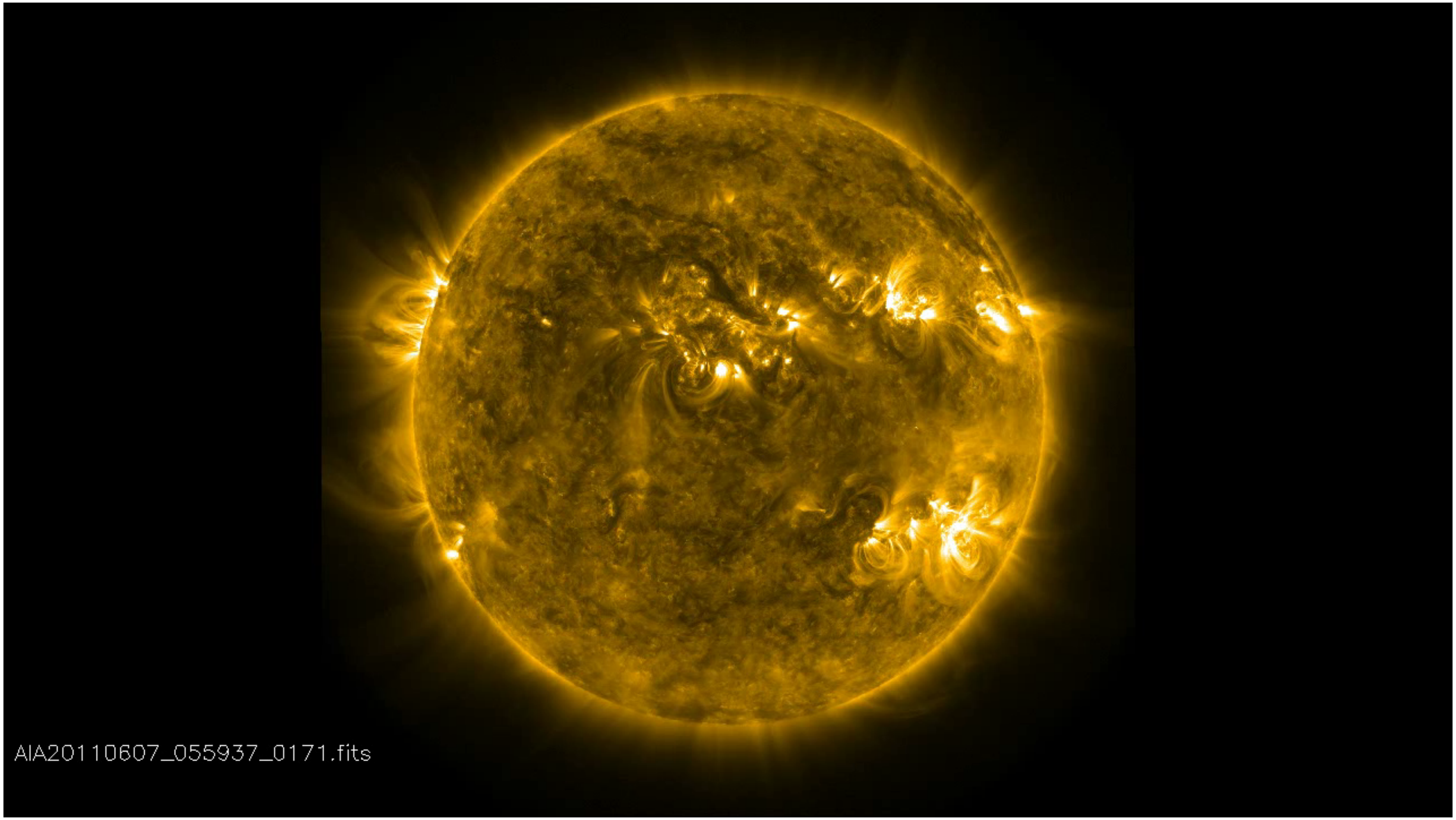




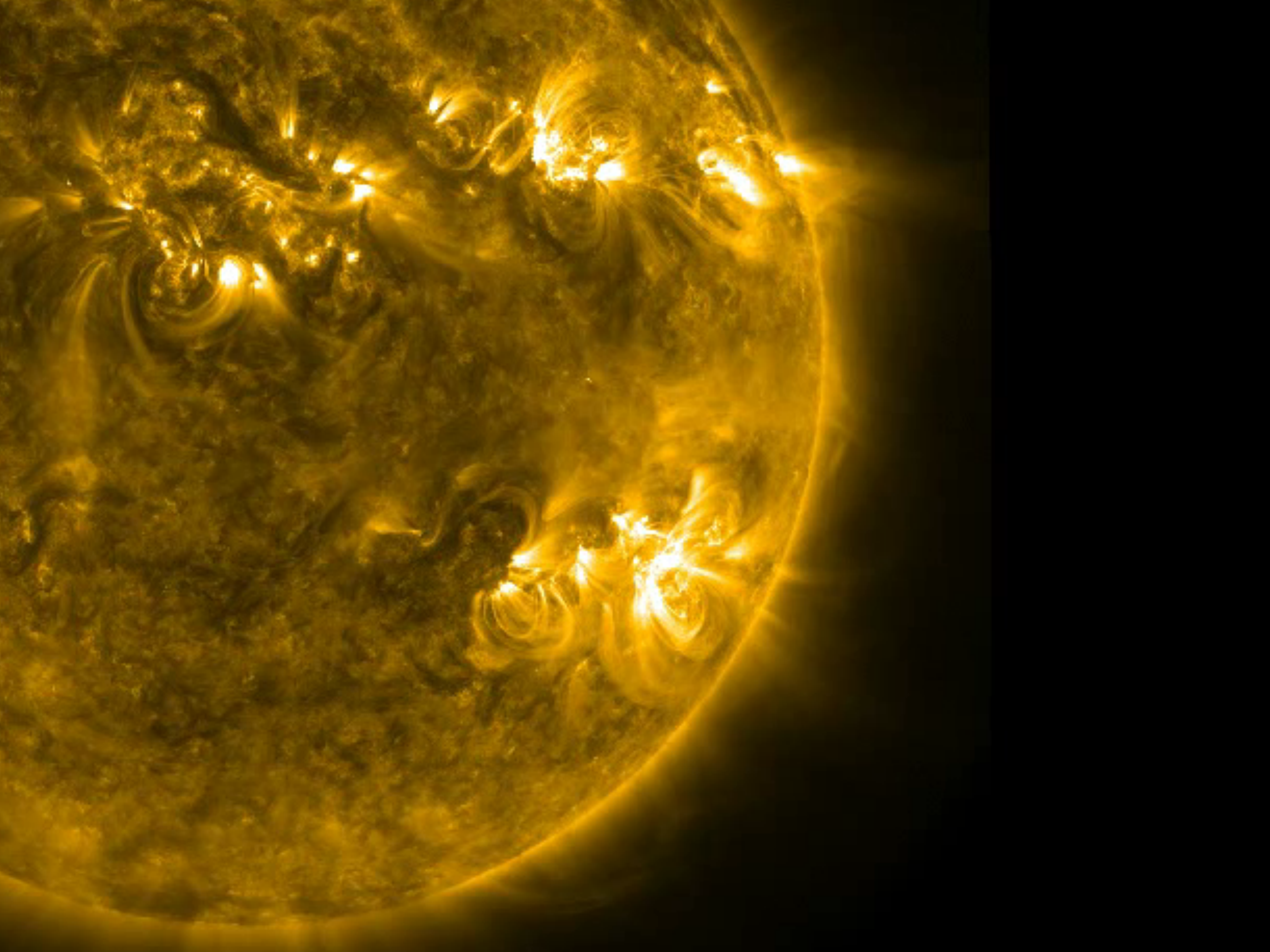
Accretion impacts: questions

- Accretion rate: UV/V/NIR $\gg$ X. Why?
- What is the role of absorption?
- What is the role of stream structuring?

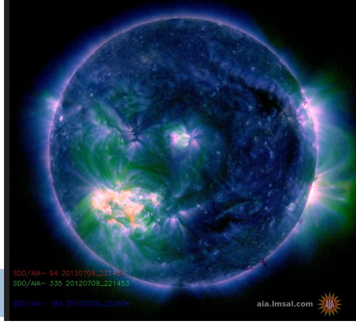
The flare and the eruption: 7 June 2011



K. Schrijver

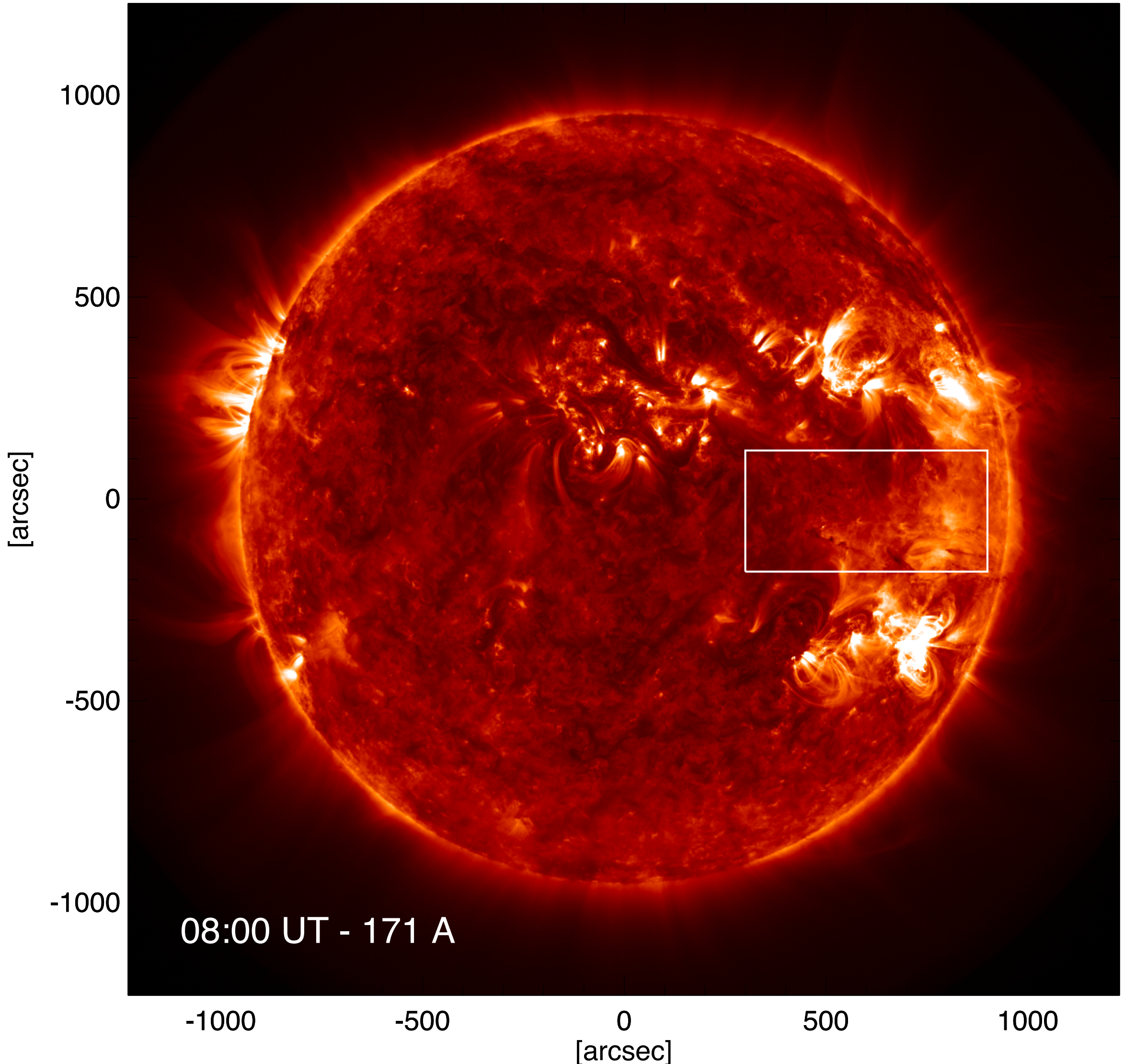


Rationale



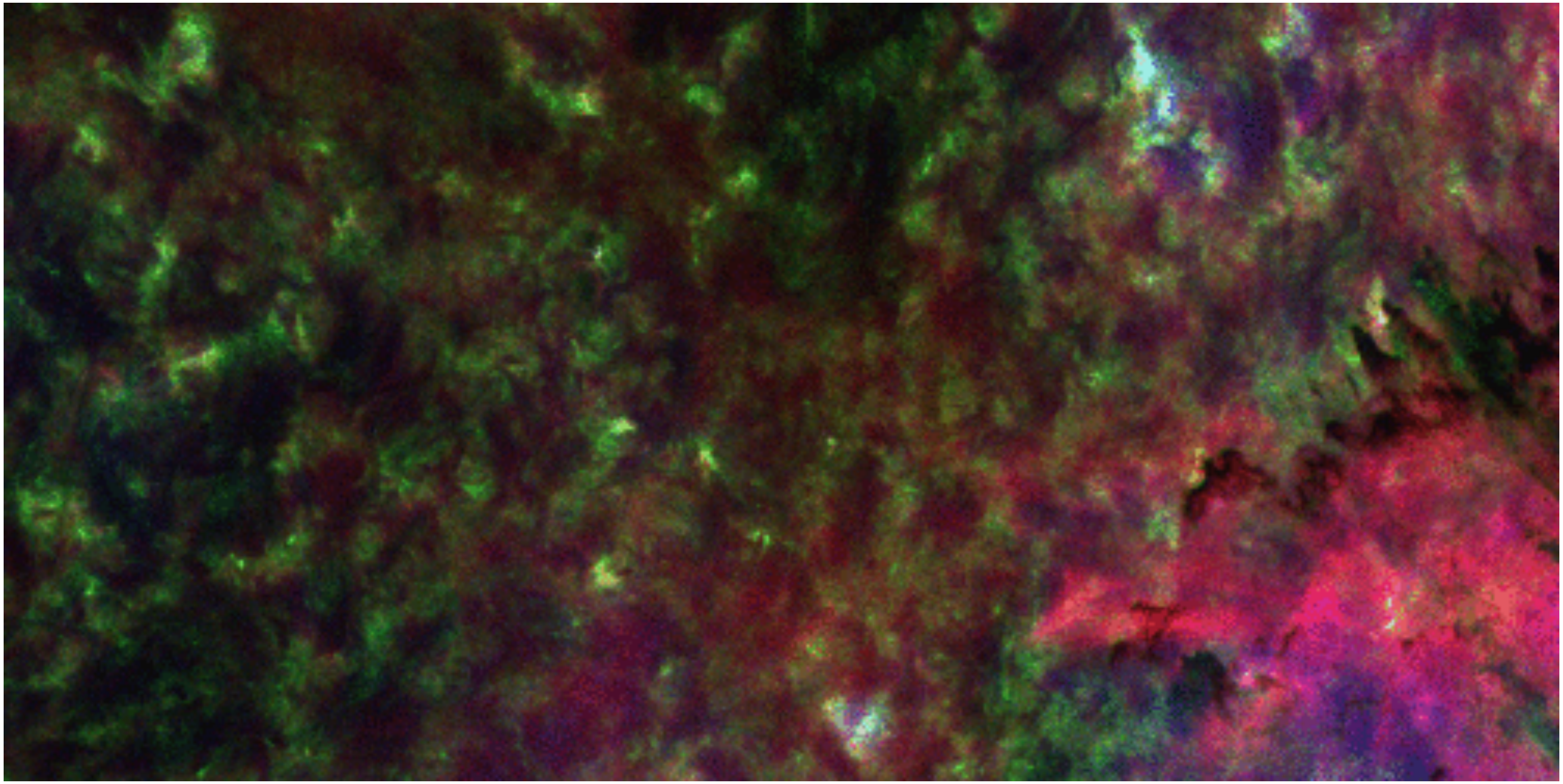
- Eruption of a filament from solar flare (June 7, 2011) - Solar Dynamics Observatory (SDO)
- Ejecta fall back onto the solar surface
- Impacts bright in UV/EUV
- Similar to accretion on YSO
- High-resolution hydrodynamic 2D simulations

The impacts region



F. Reale
P. Testa

3-color movie: 171A (R), 304A(G), 335A(B)



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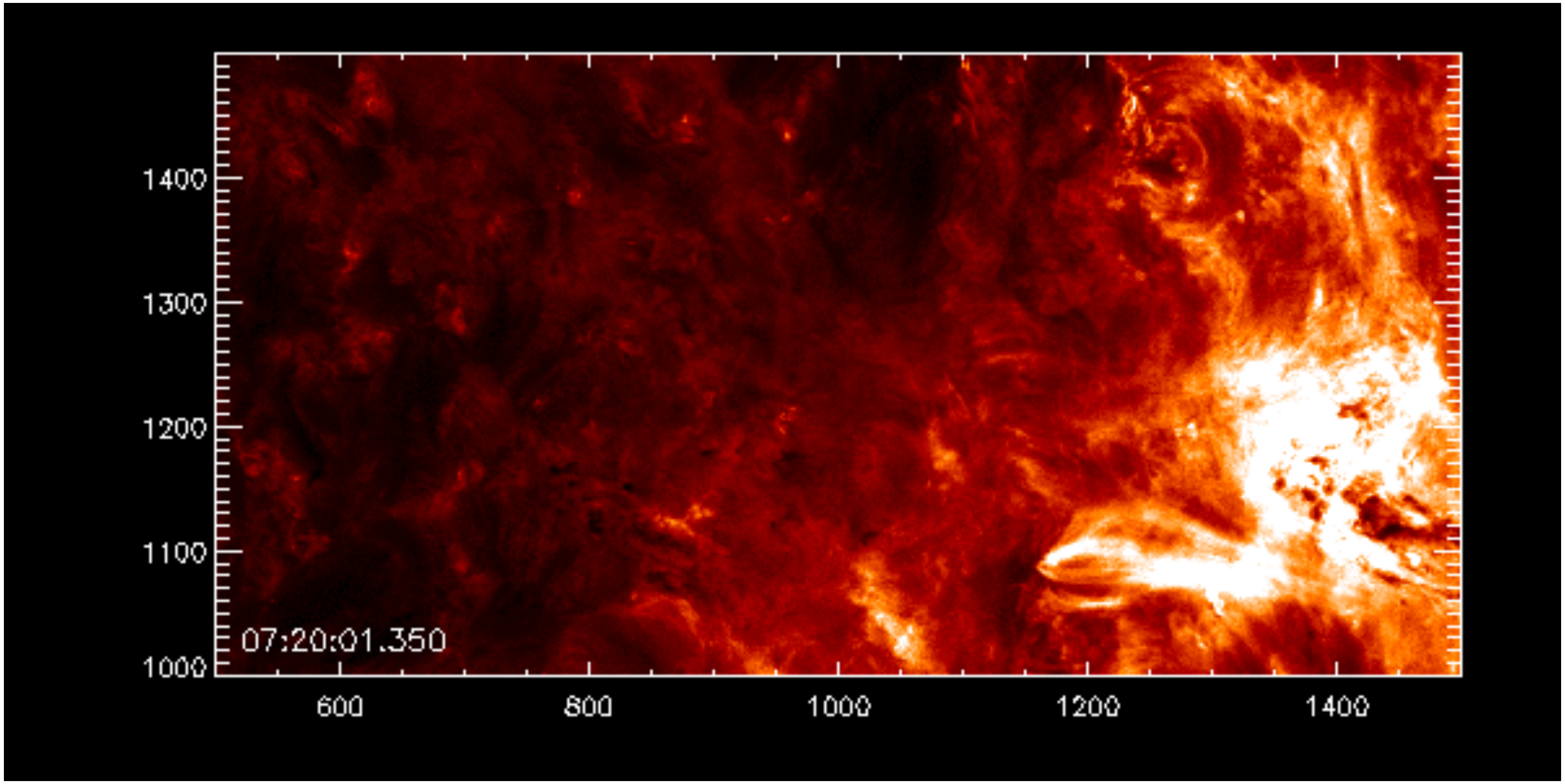
Close up: 171 A (Fe IX, logT~5.9)



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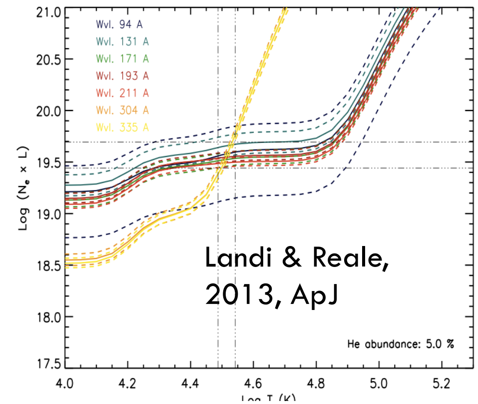
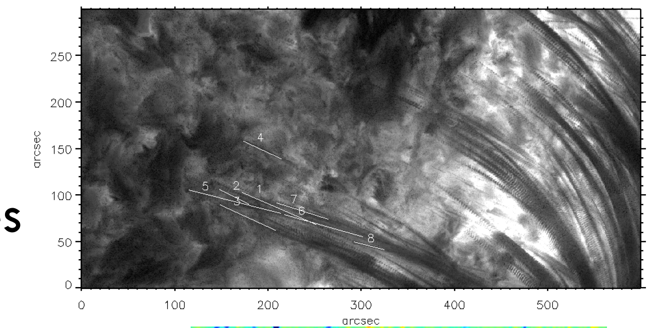
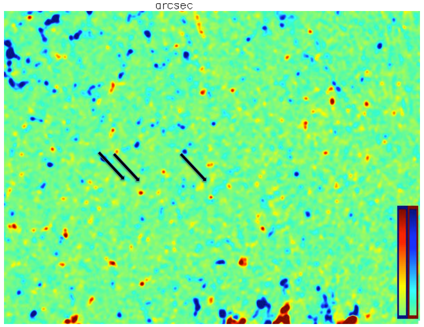
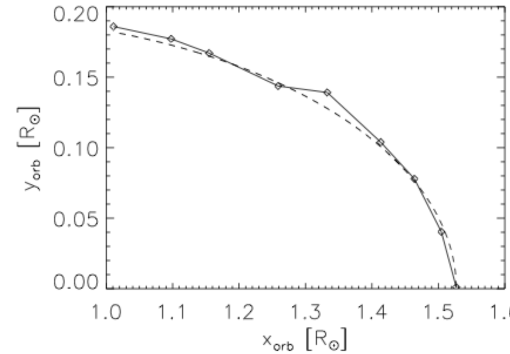
Data analysis

- Impacting plasma:
  - Density: $2 < n < 10 \times 10^{10}$ cm^{-3} (from absorption)
  - Velocity: $300 < v < 450$ km/s (from images and STEREO data)
  - Size: r~2000-4000 km, l~2000-10000 km
- Weak magnetic field ($\beta >> 1$, HMI)
- Free fall (STEREO)



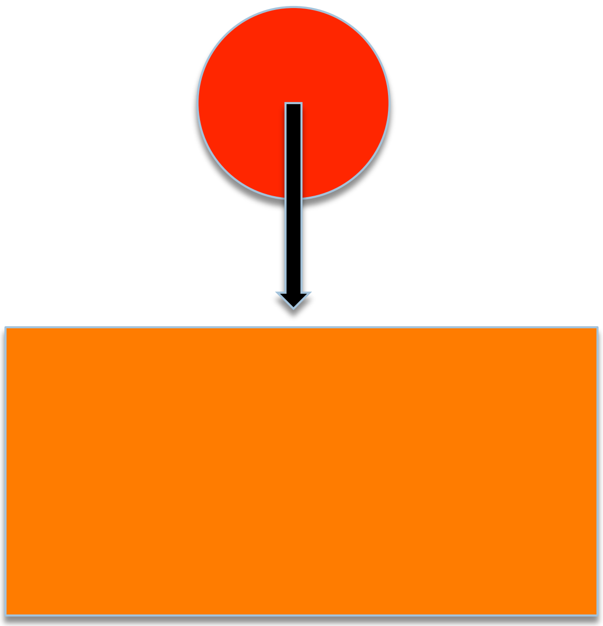






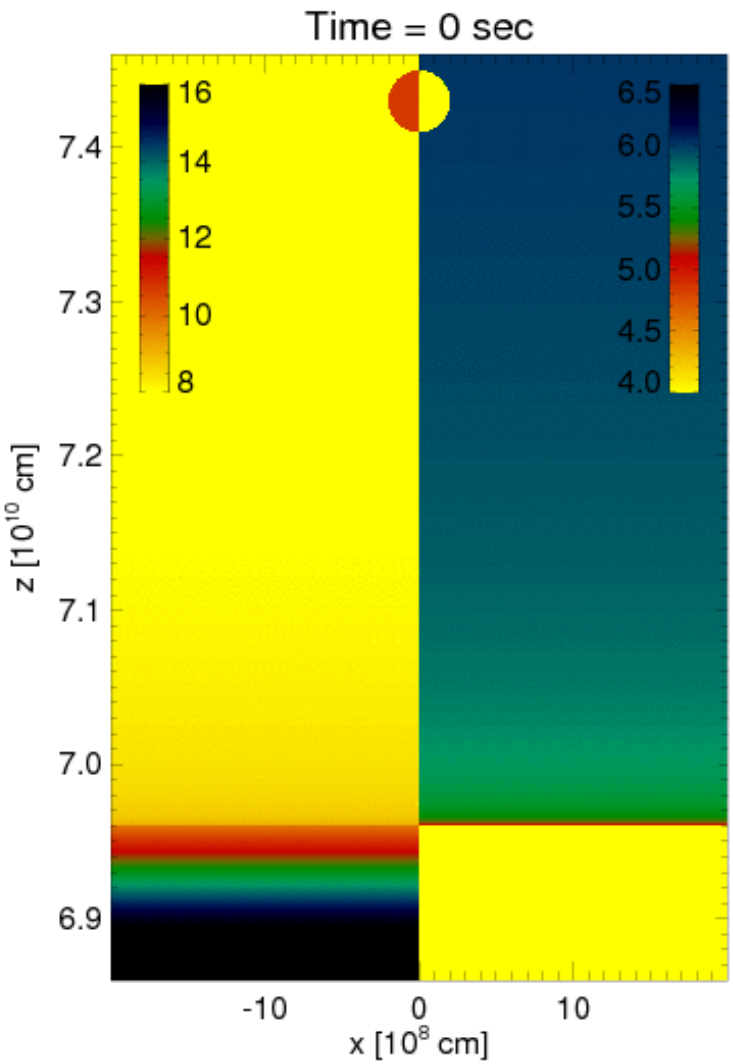
Hydrodynamic simulations

- Hydrodynamic model of plasma blobs downfalling in a low-density (10^8 cm^{-3}) corona
  - Impact speed: 400/500 km/s
  - Density: 5×10^{10} cm^{-3}
- 2D cylindrical geometry
- Spatial resolution: 5 km
- Radius: 2000 km
- FLASH code (Fryxell et al. 2000)



S. Orlando, F. Reale, G. Peres

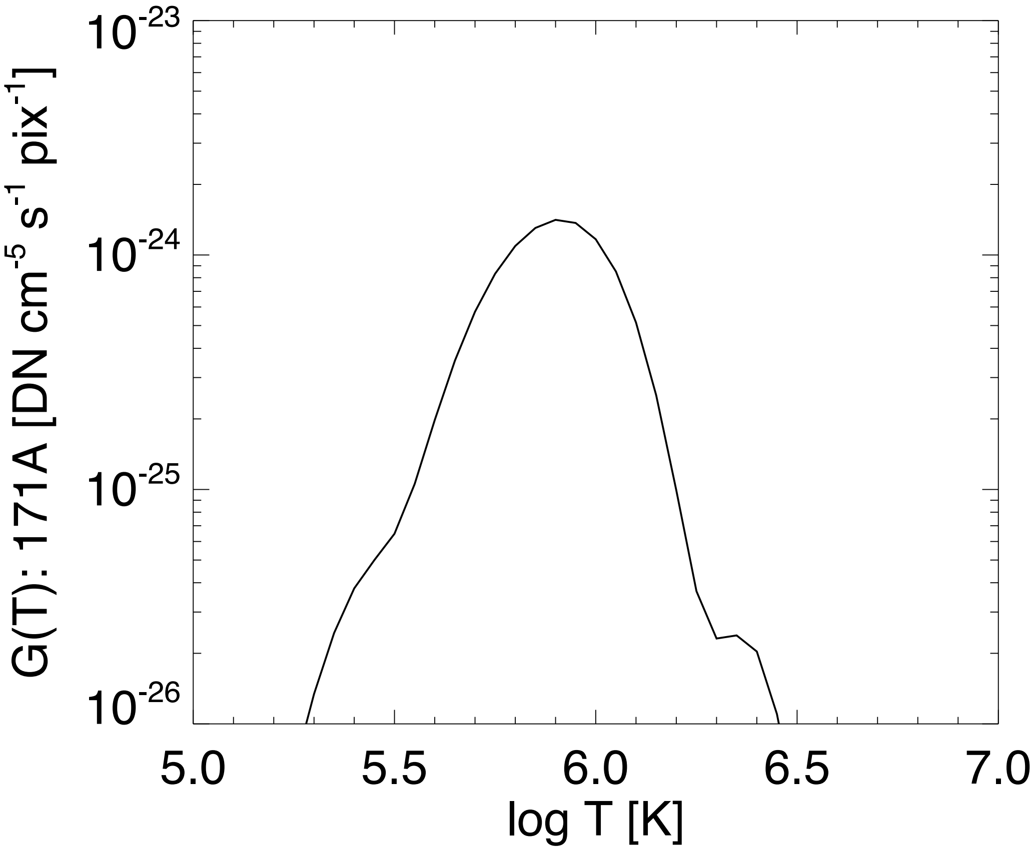
Simulation of a droplet



Density Temperature

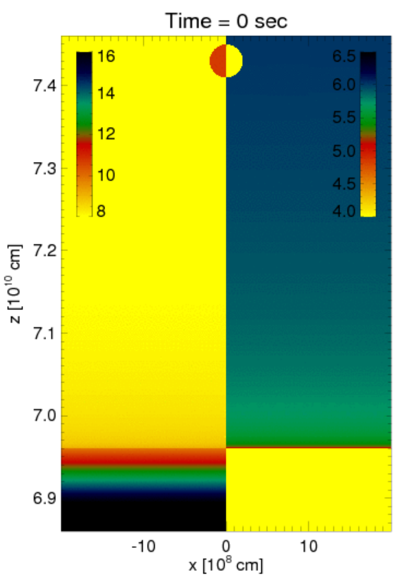
Synthesis of emission

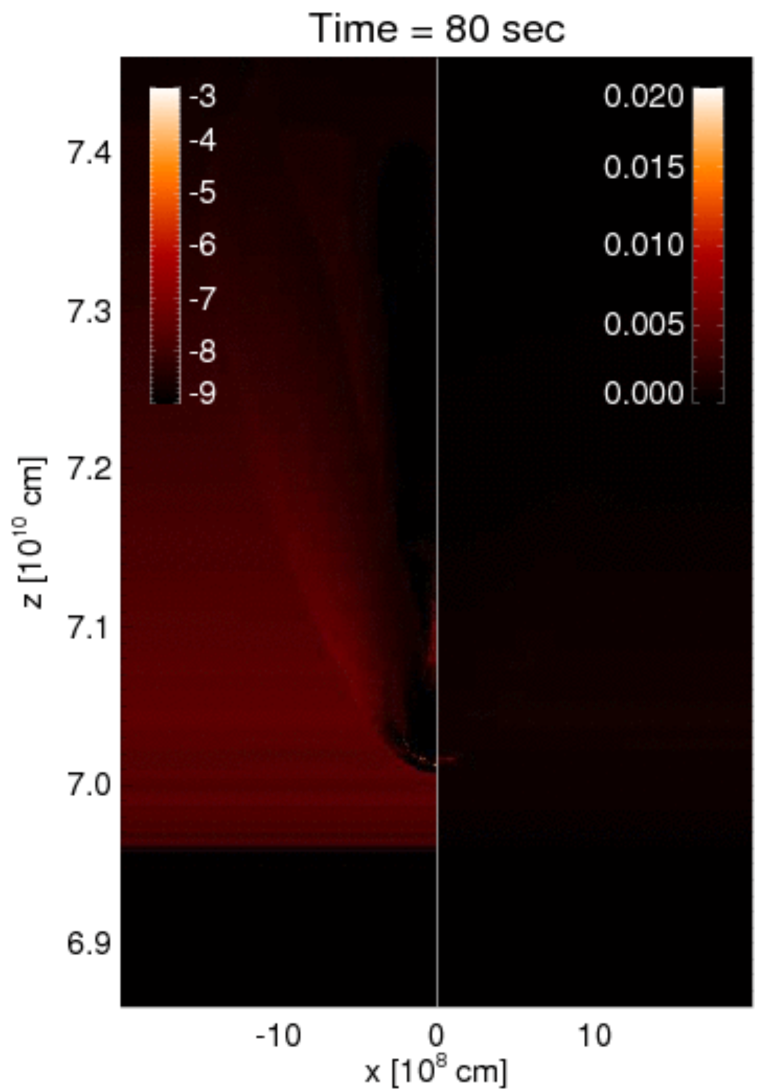
- 171 A channel
- Fe IX line
- T ~ 10^6 K



Droplet emission

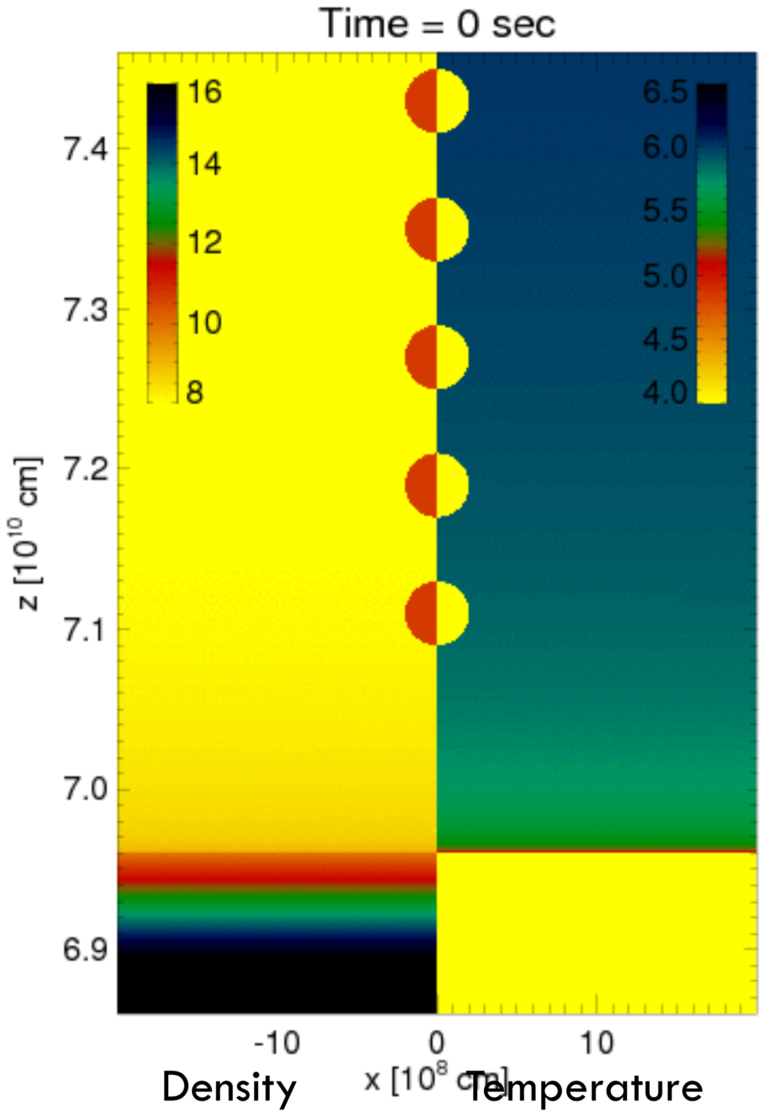
- Most below TR
- Emitting plasma:10%





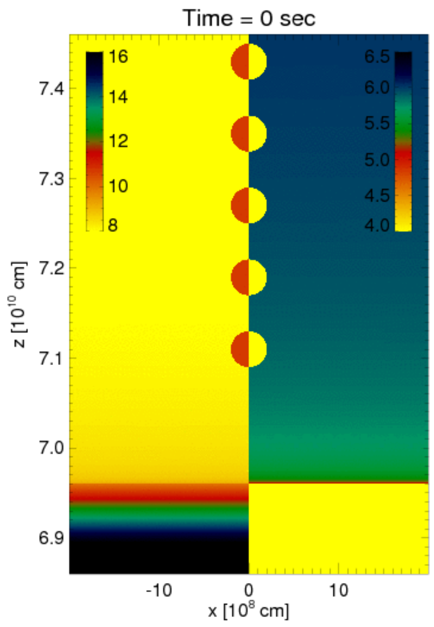
Cross-section Integrated

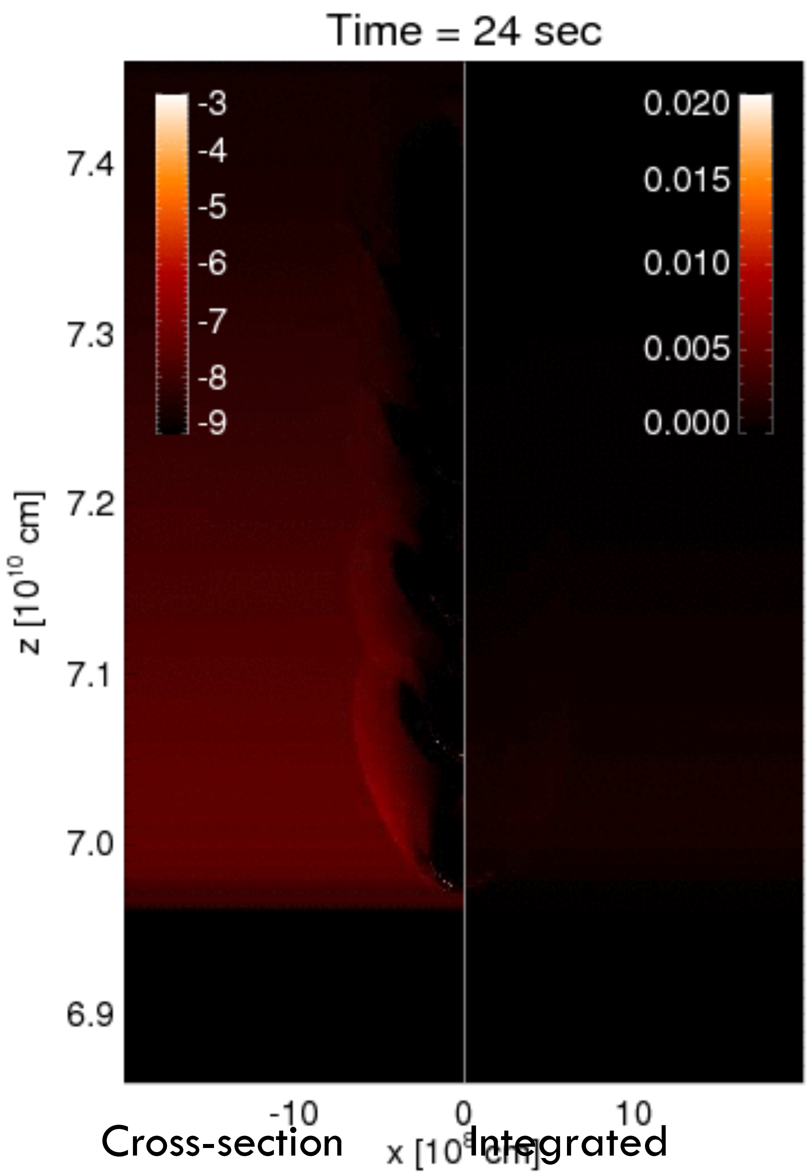
Train of droplets



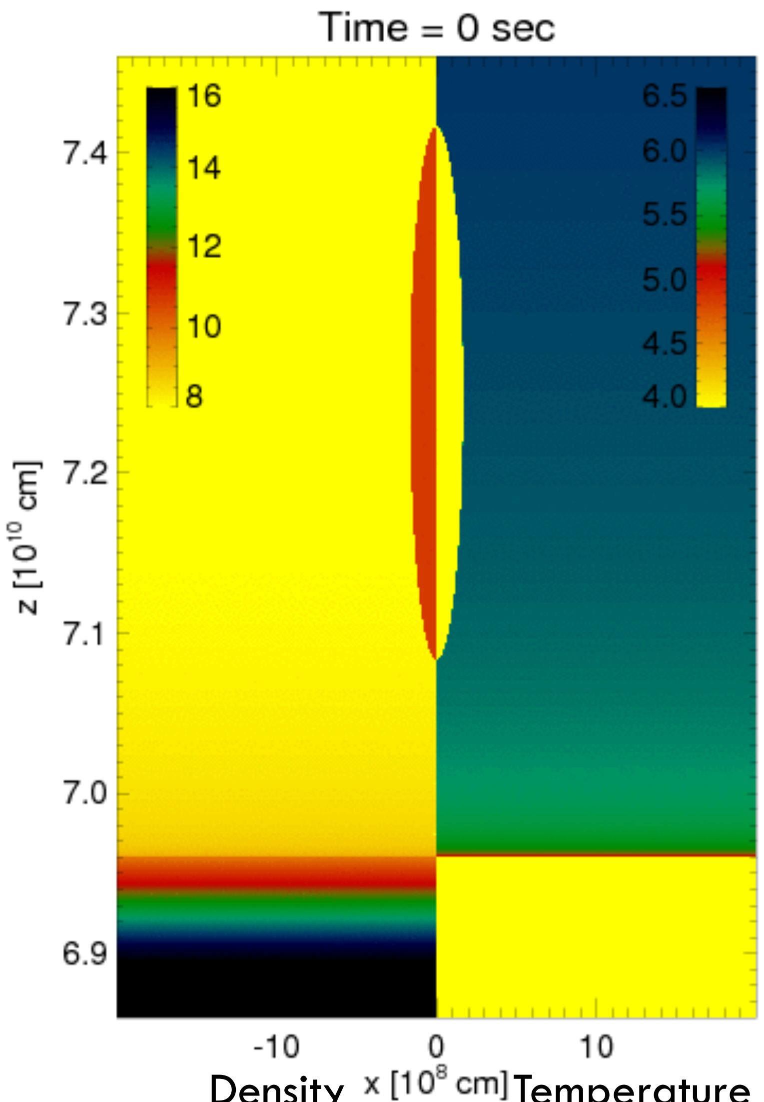
Train of droplets: emission

- Emitting plasma: 7%





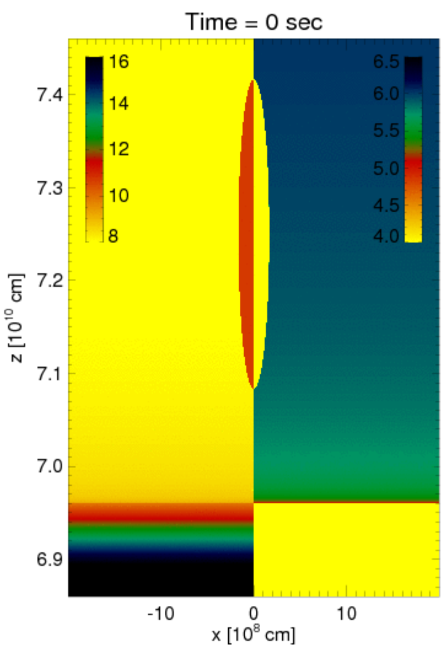
Stream

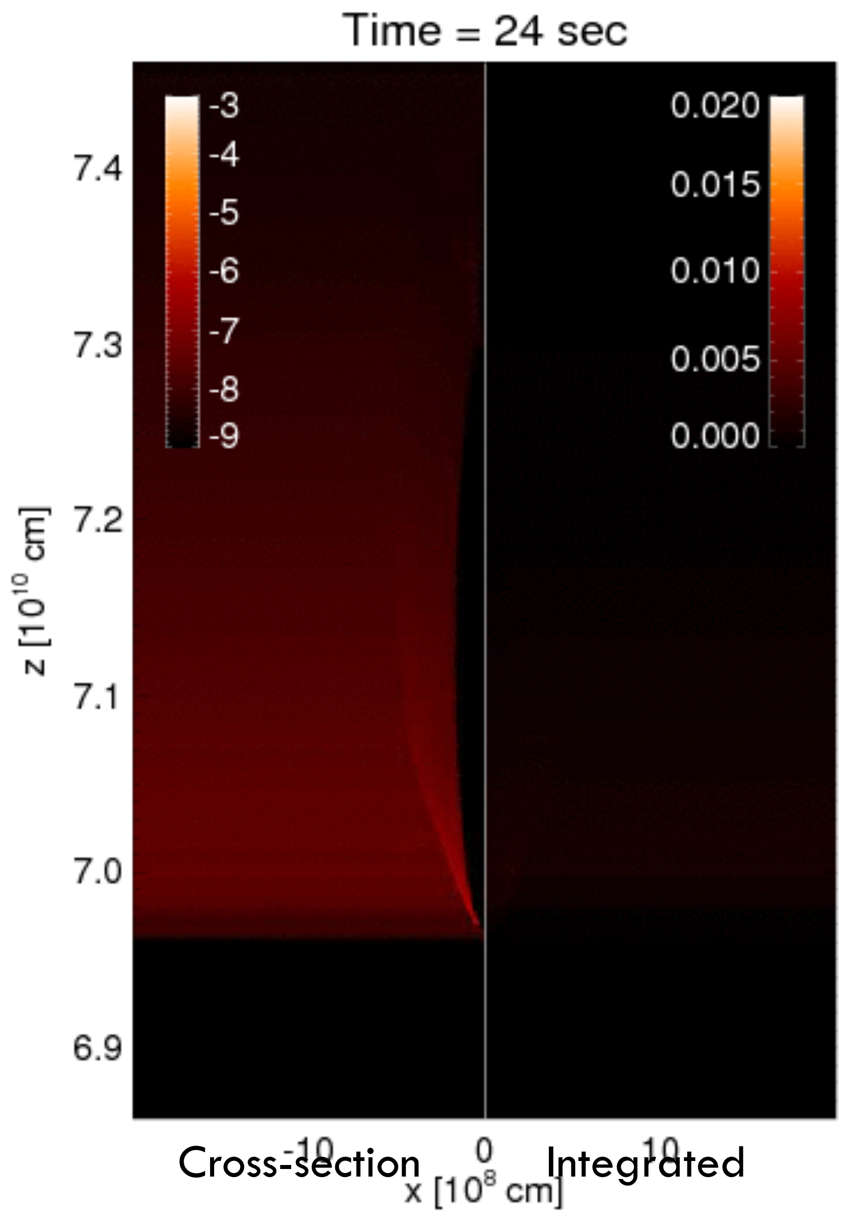


Density Temperature

Stream: emission

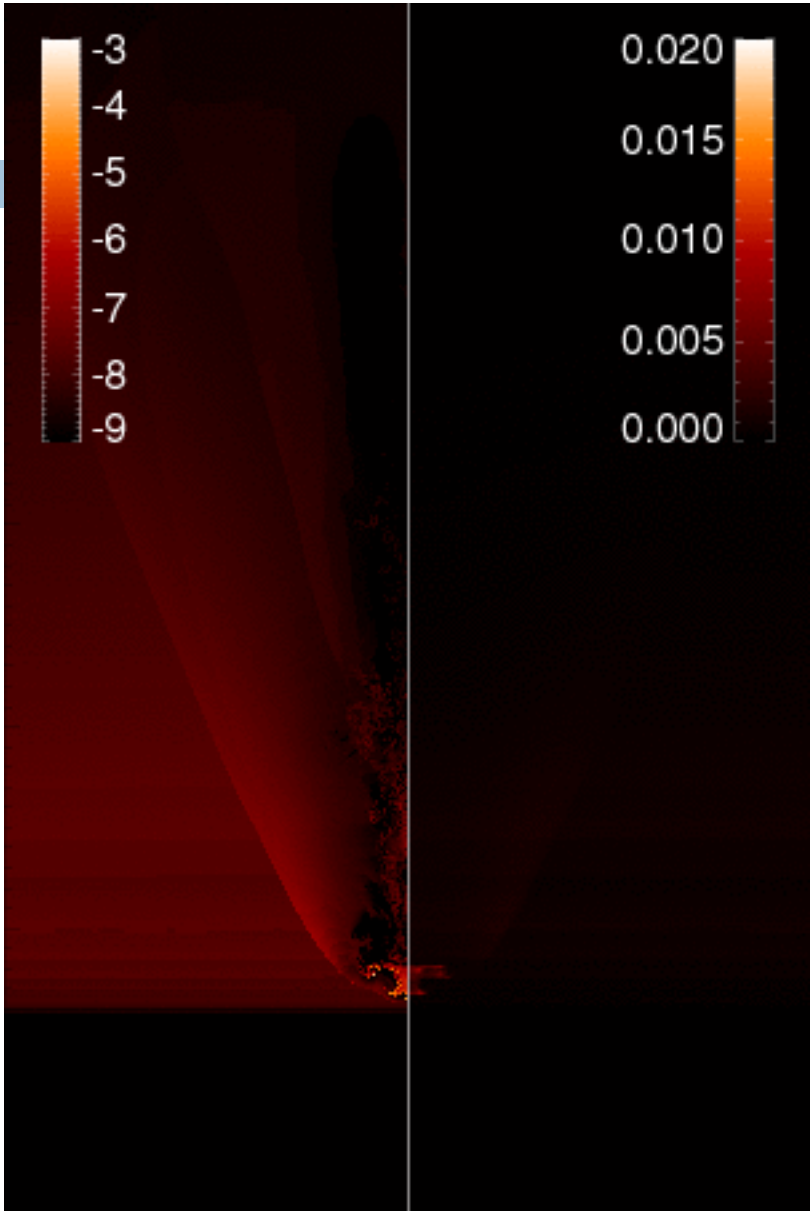
- Emitting plasma: 24%





Low density

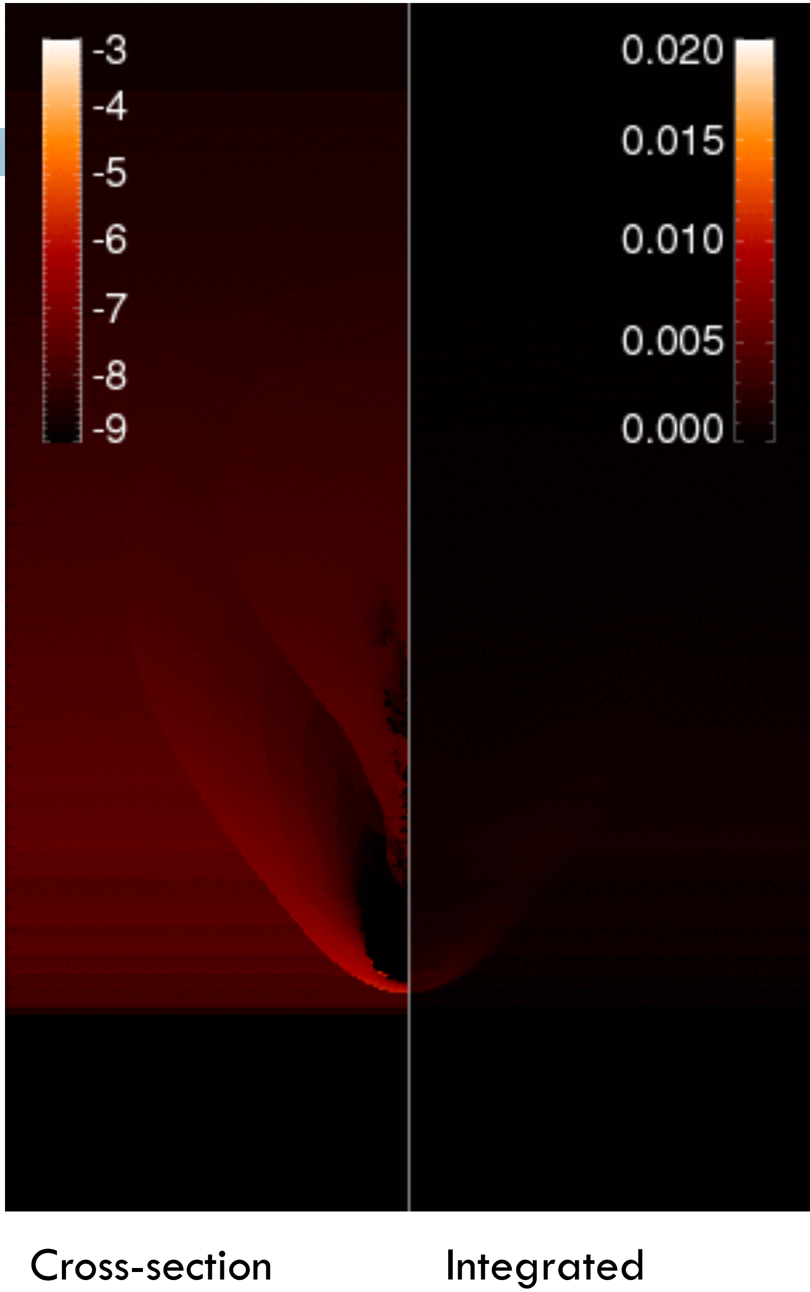
- Density: 5×10^9 cm^{-3}



Cross-section Integrated

Low speed

- Velocity: 250 km/s



Hints/results stars vs Sun

Stars	Sun
Density: $10^{11}-10^{13}$ cm^{-3}	Density: 5 10^{10} cm^{-3}
Velocity: 400-500 km/s	Velocity: 300-450 km/s
Temperature: 2 – 4 MK	Temperature: ~1 MK
Accretion rate: 10^{-12}- 10^{-7} $M_\odot$/yr	Accretion rate: 10^{-14} $M_\odot$/yr
?	Absorption -> Emitting mass: 5-25%
	Emission from disk material
	Role of fragmentation

Perspectives

- Bright spots due to impacts of plasma with:
  - High-density ($\gg 10^{10}$ cm^{-3})
  - High velocity (300-500 km/s)
- Similar to high energy emission from stellar accretion impacts
- High energy emission from the original fragment material
- Accretion rates X-rays < UV/optical/NIR: absorption by opt. thick plasma
- Laboratory to study the impact of dense accreting circumstellar material