Examining Accretion Disk Properties of Sgr A*

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Properties of Sgr A*

- Quiescent luminosity of . (Baganoff et al., 2003)

- Short duration X-ray flares by NuSTAR (few hours). (Barrière et al., 2014 or wait till a few presentations from now!)

- We will discuss month-long X-ray flares. (Christie et al. in prep.)
Gas Density around Sgr A*

- Sgr A* is an ideal place to study quiescent accretion and properties of geometrically thick disk.

- At Bondi Radius (~$10^5 R_g$), Chandra resolves X-ray, thermally emitting gas with density $\rho$. (Baganoff et al. 2003)

- Very close to the black hole (~), Faraday rotation constrains mass-loss rate at $M_w$. (Marrone et al. 2007, Mos´cibrodzka et al. 2009)

- We aim to study properties of the disk between two boundaries.
Stars in Galactic Center: The S-Cluster

- Massive, B-dwarf stars with powerful winds of .

- The brightest star, S2, is characterized by a close pericenter passage of ~3000 R_g and mass loss rate \( M_w \) (Martins et al., 2008)

- These stars, specifically S2, are good probes of the accretion disk. (Giannios & Sironi, 2013)
Stellar Wind – Accretion Disk Interactions

- Interactions cause the formation of a bow shock in stellar wind of star.
Determining Shape of Termination Shock

- Assumptions for semi-analytical model:
  i) The system has reached a steady state.
  ii) The shocked wind region falls within the thin shell limit.

- Follow an analysis of momentum supported bow shocks. (Wilkin, 1996)

- Include thermal pressure of disk: $P_{therm}$
Properties of Shocked Stellar Wind

- Using Rankine-Hugoniot conditions derivations of $T_{SW}$
- thermal bremsstrahlung power

Christie et al. in prep.
Testing Our Model Through Hydro-Simulations

- Used to make comparisons of:
  - Our estimates of the termination shock and contact discontinuity.
  - Thermal bremsstrahlung power produced from the shell.

- Large back region beyond termination shock is dominated by Kelvin-Helmholtz instabilities.
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Termination Shock & Contact Discontinuity

- These surfaces are quickly prone to instabilities.

- Estimates for these interfaces valid up to $\frac{\pi}{2}$. 

Christie et al. in prep.
Bremsstrahlung Emission from Shell

- Computation of bremsstrahlung emission produced from the shell is permitted up to with $M_w$
- Consider wind compositions of hydrogen and solar metallicities.
- $L_{\text{Hydrogen}}^{3/2} n_d^{1/2} v_w^{-1/2}$

Christie et al. in prep
Contributions from Back Region

- Bremsstrahlung emission produced by all shocked wind computed as a function of both $\alpha$ and $z$.

- Back region contributes large fraction to total luminosity (~10 times that produced from the shell).
Evolution of Back Region

- Time dependent density used to model transit through pericenter and observe evolution of “mixing” region.
Summary

- Thermal pressure of the accretion disk substantially affects the emission.

- Radiation from tail of bow shock structure dominates emission.

- The passage of a star through the accretion disk of Sgr A* produces a bow shock while an observable, month-long X-ray flare may be expected with luminosities.
Simulation Setup

- Performed using hydrodynamic code MRGENESIS (Mimica et al. 2009)
- 3rd order Runge-Kutta scheme for time integration.
- Piecewise-parabolic method for spatial interpolation (Colella & Woodward 1984).
- Reflective boundary conditions along symmetry axis.