The Disruption of Magnetized Gas Clouds in the Galactic Center

Ann-Marie Madigan
UC Berkeley

Mike McCourt, Ryan O’Leary & Eliot Quataert
G2 gas cloud

Gillessen et al (2013)

$m \sim 3M_{\oplus}$
$e \sim 0.98$
$P \sim 300$ Yr
$r_p \sim 0.001$ pc
$r \sim 100$ AU
Tidal shearing of gas by black hole

Pfuhl et al (2014)
Predictions from hydrodynamics if G2 is gas cloud

1. Cloud disrupts on timescale $<<$ orbital period & mixes with plasma
2. Insignificant drag force at periapse - no deviation of orbit from Keplerian
MHD

Hydro

Cloud: tangled magnetic field
Wind: straight lines

McCourt et al (2014)
Internal tangled B-field of cloud

\[ c = \frac{\sqrt{\langle \rho^2 \rangle}}{\langle \rho \rangle} \]

\[ t_{cc} = \left( \frac{\rho_{\text{cloud}}}{\rho_{\text{wind}}} \right)^{1/2} \frac{R_{\text{cloud}}}{v_{\text{wind}}} \]

McCourt et al (2014)
External B-field in wind

McCourt et al (2014)

\[ \mathbf{F}_{\text{drag}} \sim \rho_{\text{wind}} v_{\text{wind}}^2 r_{\text{cloud}}^2 \times \left( 1 + \frac{v_A^2}{v_{\text{wind}}^2} \right) \]
Results from 3D MHD

Magnetized gas clouds:

1. break-up but do not mix entirely into plasma.

2. experience a greater drag force than hydrodynamics predicts.

\[ F_{\text{drag}} \sim \rho_{\text{wind}} v_{\text{wind}}^2 r_{\text{cloud}}^2 \times \left( 1 + \frac{v_A^2}{v_{\text{wind}}^2} \right) \]
(Re-)discovery of G1

Pfuhl et al. (2014)

1. Cloud survived passage through periapse 13 yrs ago
2. Strong drag force changed (a,e) 

G1 & G2 are bright knots in a larger gas streamer orbiting the massive black hole
Future work

1. Lifetime of gas clouds in the Galactic center
2. Size of ‘cloudlets’/knots
3. Constraints on density & temperature of accretion flow