Mon. Not. R. Astron. Soc. **000**, 1–1 (2011) Printed 12 July 2016 (MN LaTeX style file v2.2)

clumps

12 July 2016

1 DERIVATION

Lets assume that a given clump of radius R$_c$ expands at velocity v adiabatically due to its internal gas pressure:

$$m_p v^2 = 3kT \rightarrow v = \sqrt{\frac{3kT}{m_p}} = \frac{dR}{dt} \quad (1)$$

We want $\tau(t)$:

$$\tau(t) = 2\kappa\rho(t)R(t) \quad (2)$$

Lets assume a starting density, ρ_0 so that:

$$\frac{\rho(t)}{\rho_0} = \left(\frac{R_c}{R(t)}\right)^3 \quad (3)$$

$$R(t) = R_c + \sqrt{\frac{3kT}{m_p}} * t \quad (4)$$

so

$$\tau(t) = 2\kappa\rho_0 * R_c^3 \left[R_c + \sqrt{\frac{3kT}{m_p}} * t\right]^{-2} \quad (5)$$

Based on the simulations of Jiang, Stone and Davis (2014) we can roughy gauge Σ/Σ_0 (Fig 11) and can therefore say that:

$$\rho_0(r) = \rho_{0,s} * \left(\frac{r}{r_s}\right)^{1.75} \quad (6)$$

where the subscript s indicates the value at the spherization radius. Lets now assume that the clump is launched from its position in the disc (with scale height h/r) with the vertical component of the escape velocity:

$$D = r\sqrt{\left(\frac{h}{r}\right)^2 + 1} \quad (7)$$

$$v_{esc} = \sqrt{\frac{2GM}{D}} \quad (8)$$

$$h = v_{esc,y} * t = \frac{1}{sin\theta}\sqrt{\frac{2GM}{D}} * t \quad (9)$$

the $sin(\theta)$ comes from taking the vertical component of the escape velocity and $\theta = arctan(h/r)$. Note that T is a function of radius and as we have a large scale height (rad pressure supported flow) goes as r$^{-1/2}$. Using the temperature at the spherization radius (r$_s$ $= \dot{m}_0 * r_{in}$ and $\dot{m}_0$ is the mass transfer rate in units of Eddington):

$$T = T_s\left(\frac{r}{r_s}\right)^{-1/2} \quad (10)$$

We now need to consider the impulse from the inner regions which has luminosity L_{in} and we assume to radiate isotropically.

$$F = \frac{L_{in}\sigma}{4\pi D^2 c} = \frac{dp}{dt} = \frac{m_p(v_{final} - v_{initial})}{dt} \quad (11)$$

For simplicity lets assume that the launching happens at the same time as the clump gets removed from the disc so that $v_{initial} \approx 0$. v_{final} = dz/dt where z is in the direction pointing away from the BH radially (i.e. the vertical component is $z * sin(\theta)$):

$$z = \frac{L_{in}\sigma t^2}{8\pi D^2 c m_p} \quad (12)$$

so after a time t for the clump to expand and become optically thin we find its moved vertically to h + z*sin(θ) and horizontally to z*cos(θ).

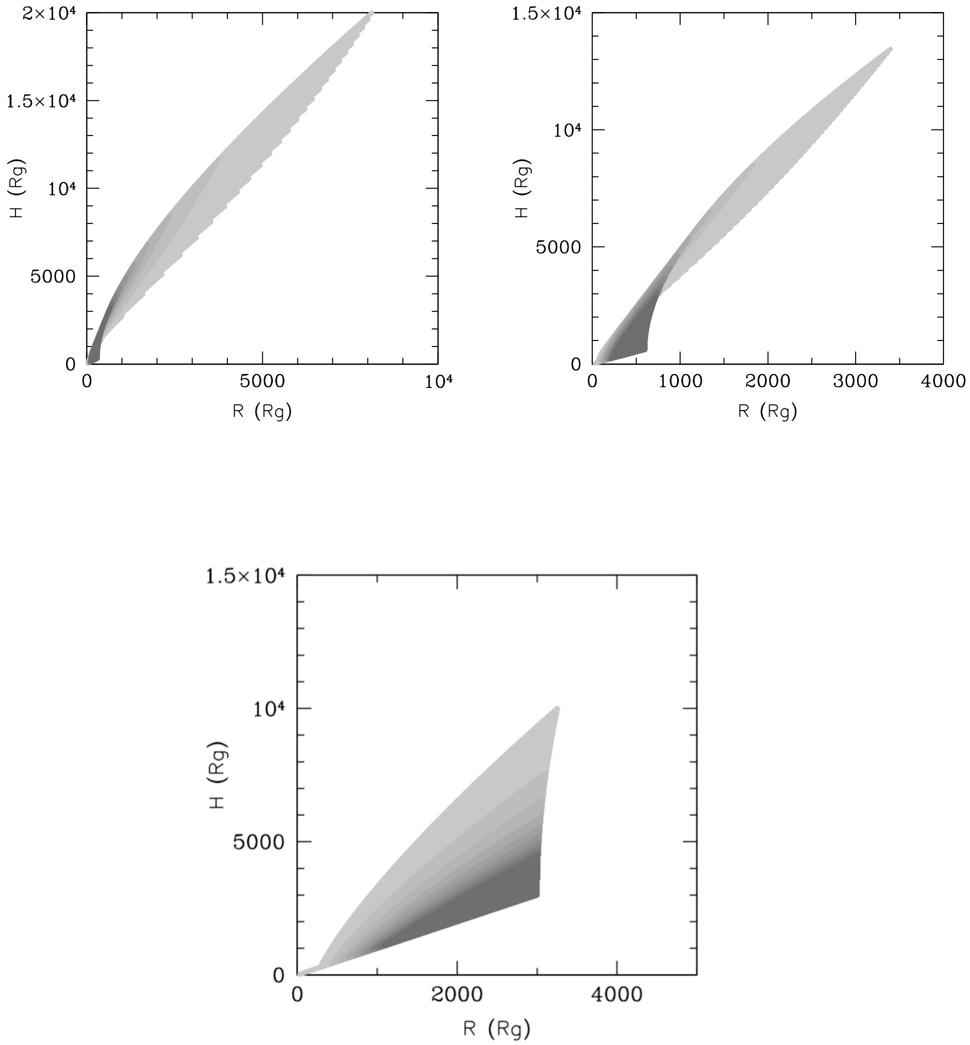

Figure 1. clockwise from top-left: accretion at 50×Edd, 100×Edd and 500×Edd.

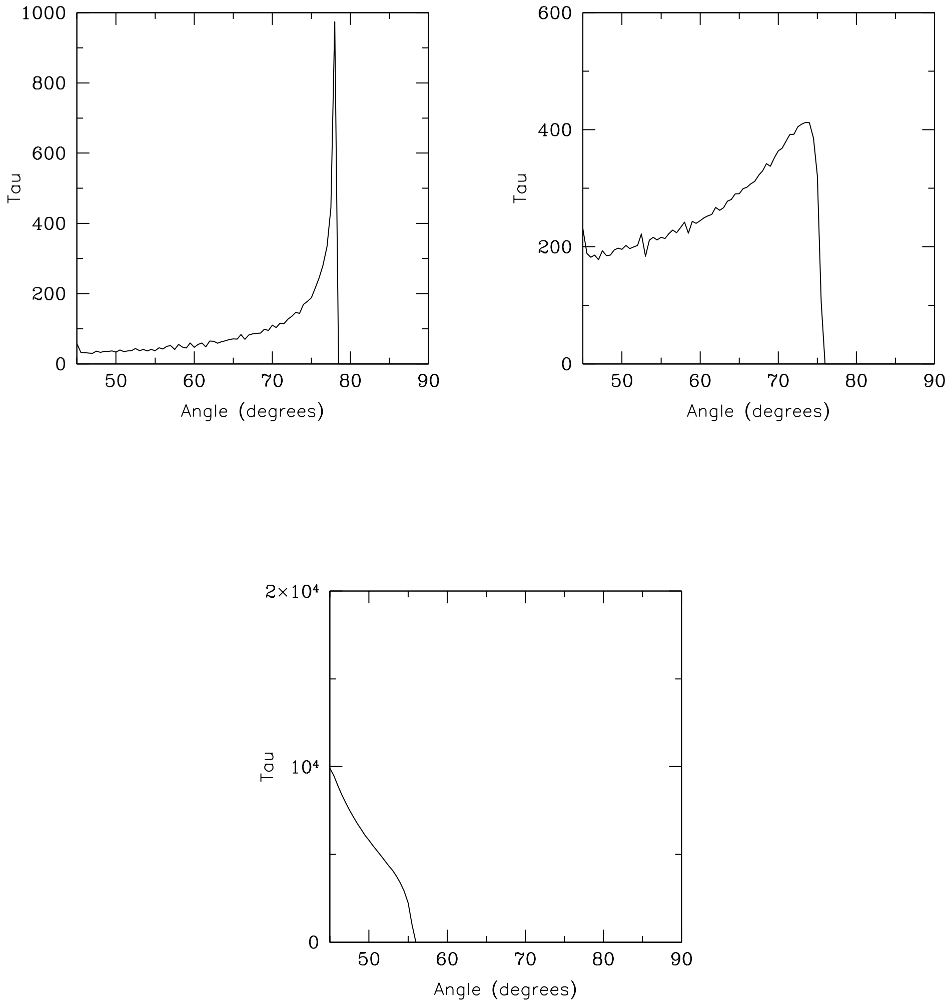

Figure 2. clockwise from top-left: accretion at 50×Edd, 100×Edd and 500×Edd.