(PHY/AST 564; Blackman; Fall 2003) Problem Set 1

1.

a) Explain why the plasma frequency (derived in class) does not depend on temperature, and why the ion-electron equilibration time does. You may consult Spitzer (Phys of Fully Ionized Gases (on reserve) 5.1-5.3).

b) Explain why charge neutrality can hold even over time scales $<<$ ion-electron equilibration times. How does this apply to the Galactic center?

c) Order the following equilibration times from shortest to longest and explain physically the ordering: t_{pe}, t_{ee}, t_{ie}.

2.

a) Derive the speed of sound for a monatomic adiabatic gas. Hint: Linearize the fluid equations for a stationary unperturbed state such that $P = P_0 + P'$, $\rho = \rho_0 + \rho'$, $\mathbf{v} = \mathbf{v}'$, where the 0 is the unperturbed steady state, and the perturbations are time dependent. Obtain a wave equation for ρ' to determine the sound speed.

b) Obtain a numerical value for the Galactic center X-ray gas.

c) Derive the condition for justification to ignore pressure gradients in a gas, and explain physically.

3. Assume that the radiated luminosity from accretion onto a black hole is $L = 0.1\dot{M}c^2$, where $\dot{M}$ is the accretion rate onto the hole. Consider the Galactic center, and assume the lower value $10^{-5}M_\odot/\mathrm{yr}$ on the accretion rate given in class based on stellar winds at 1pc from the Galactic center. Given only this information, can you suggest a phenomenological possibility that could account for both the X-ray cigar and the low bolometric luminosity from Sgr A? Do one calculation to justify your suggestion.