1 Introduction

Bondi Lyttleton accretion is an alluring analysis of a star flowing through a gas cloud of constant density. In extension, Bondi Hoyle accretion occurs when there is a build-up of pressure, via the accreted gas. Soon this pressure reaches a maximum and a shock is formed, causing material to fly out behind the star in the creation of a wake.
The accretion radius is what determines which gas particle collect onto the star. This radius is defined as the limit where gravitational energy overtakes kinetic. Gas found within this limit is considered bound to the star. This radius R_a that creates this limit is found by:

$E_{tot} > 0$: No Accretion
$E_{tot} = 0$: Limit
$E_{tot} < 0$: Completely Accreted

$$E_{tot} = 0 \tag{1}$$

$$E_{tot} = \frac{1}{2}mv_\infty^2 - \frac{GmM}{r} = 0 \tag{2}$$

$$\frac{1}{2}v_\infty^2 - \frac{GM}{r} = 0 \tag{3}$$

$$R_a = r = \frac{2GM}{v_\infty^2} \tag{4}$$

Where v_∞^2 is the velocity of the gas and M is the mass of the sink being flown through the gas.
Gas approaching this star at a distance (from the particles center to the axis on which the star lies) less than the accretion radius, will not have enough kinetic energy to liberate itself from the stars gravitational pull. It is worth mentioning that due to the high velocity of the gas and the large gravitational pull of the star, the accreted gas falls on to, as well as behind, the star. The rate in which this falling gas accretes onto the star can be descried by its mass loss equation, $\dot{M}$:

$$\dot{M} = \frac{dM}{dt} = \frac{\rho V}{dt} \tag{5}$$

$$V = Av_\infty \; dt \tag{6}$$

Replace V in equation 5 with equation 6.

$$\dot{M} = \frac{\rho A v_\infty dt}{dt} \tag{7}$$

$$dt = dt \tag{8}$$

Insert equation 4 into equation 3, solving for $\dot{M}$

$$\dot{M} = \rho \pi r^2 v_\infty \tag{9}$$

For an ideal, spherically symmetric star, it is expected for $\dot{M}$ to increase until it reaches a steady state.
In this review we will study Bondi Hoyle Accretion using hydrodynamical simulations in three dimensions. The goal is to eventualy be able to create an accurate representation of how multiple accreting stars, placed relatively close to one another, interact when being flown through a gas cloud of constant density. By doing this we hope to simulate similar atsronomical phenomena such as globular clusters.

2 Numerical Methods

We have executed our simulations with FLASH. This code uses Eularian computational method and a PARAMESH library to govern a block-structured grid, creating higher resolution elements only where necessary. For us, FLASH will solve the inviscid hydrodynamical equations. We give our code the initial conditions for: $\rho_\infty, \mathcal{M}, \gamma, r$. Where r is the radius of the star, M_{mach} is the mach number. With these given initial condition FLASH solves for C_s, the sound speed. Starting with the Equation of State where K is Const. and γ is the adiabatic index.

$$P = K\rho^\gamma \tag{10}$$

P and ρ are to be functions of their position, P_0 and ρ_0 plus the extremely small perturbations P' and ρ'.

$$P = P_0 + P' \tag{11}$$

$$\rho = \rho_0 + \rho' \tag{12}$$

$$\nabla P' = \gamma \left(\frac{dP}{d\rho} \right)_0 \nabla \rho' \tag{13}$$

$$\frac{dP}{d\rho} = \gamma \frac{P}{\rho} \tag{14}$$

Setting Equation 14 equal to C_s^2 yields:

$$C_s^2 = \gamma \frac{P}{\rho} \tag{15}$$

$$C_s = \sqrt{\gamma \frac{P}{\rho}} \tag{16}$$

With the sound speed calculated, FLASH is then able to solve for the velocity of the gas, v_∞, the accretion radius, R_a and finally the mass loss rate at each time step, $\dot{M}$.

In our simulations, the wind flows from the $-x$ boundary in the $+x$ direction. The $+x$ boundary is a "diode" boundary; wind may flow into but not out of this boundary type. The $\pm y$ and $\pm z$ boundaries are all considered "outflow"; our winds are free to flow into, as well as out of, this boundary type. We also give our code a maximum refinement of 7 and a minimum of 1, enabling it to increase in intervals of .3.

3 Results