Lecture 12

Wednesday, February 2, 2022 10:41 AM

Euler's Equation

$$\frac{1}{2}\left(1-\frac{c_s^2}{v^2}\right)\frac{d}{dr}\left(v^2\right) = \frac{-GM}{r^2}\left(1-\frac{2c_s^2 r_B}{GM}\right)$$

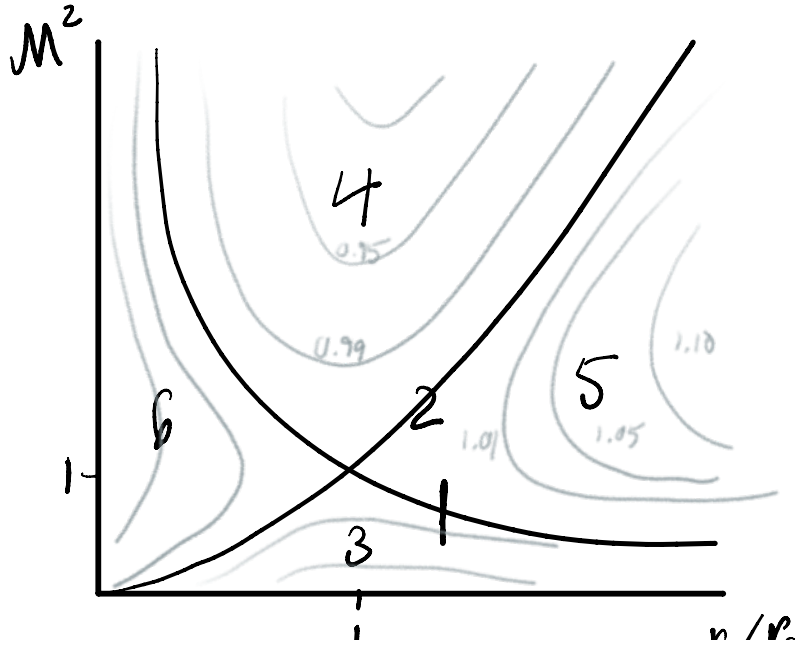
Case 1: Bondi-Hoyle

$\frac{d}{dr}(v^2) < 0$

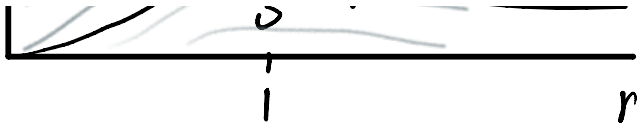
$\frac{v}{c_s}$ = Mach Number

Euler's Equation Solutions for a Circular Flow

1. Spherical Infall – Bondi-Hoyle Accretion
2. Parker (solar) wind solution
3. Stalled (everywhere subsonic)
4. Divergent (everywhere supersonic)
5. and 6. Double-valued: two v values at a fixed r requires a discontinuity → only shocks



$M = \frac{v}{c_s}$ = Mach Number



Bondi

$$\dot{M} \simeq (1.4\times10^{11}\ g\ s^{-1})\left(\frac{M}{M_\odot}\right)^2\left(\frac{n_{ISM}}{1\ cm^{-3}}\right)\left(\frac{T}{10^4 K}\right)^{-3/2}$$

($\dot{M}$ = parcel of gas)

$\dot{M} \propto A\rho v$

↳ T, P, n

$E = \eta mc^2$

↳ ~10% of rest mass turned into energy

$$L = \frac{dE}{dt} = \eta \dot{M} c^2 \sim (0.1)(10^{11})(3\times10^{10})^2 \simeq 10^{31}\ erg\ s^{-1}$$

Not observable

Stellar BH or neutron star

$L \sim 10^{35-38}\ erg\ s^{-1}$ Not Bondi-Hoyle accretion

SMBH M87

$$\dot{M}_B \simeq (2\times10^{23}\ g\ s^{-1})\left(\frac{M}{3\times10^9}\right)^2\left(\frac{n}{10^{-2}\ cm^{-3}}\right)\left(\frac{c_s}{400\ km/s}\right)^{-3}$$

↓

0.003 $M_\odot$/yr

$$L = \eta \dot{M} c^2 = (2\times10^{43}\ erg\ s^{-1})\left(\frac{M^2}{M_{87}}\right)\left(\frac{n}{10^{-2}\ cm^{-3}}\right)\left(\frac{c_s}{400\ km/s}\right)^{-3}$$

MW

N stellar mass BHs SFH

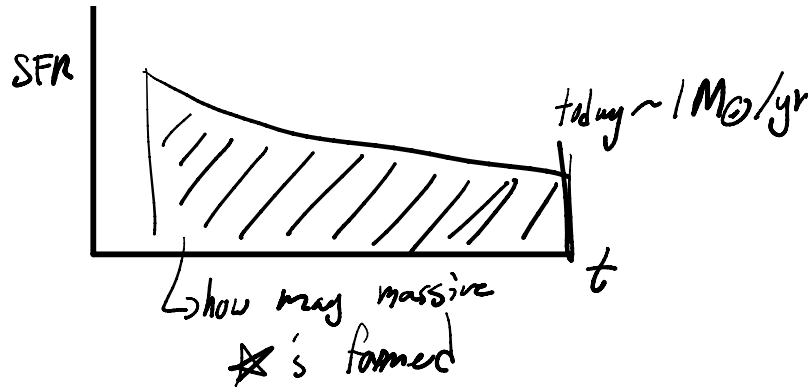
SFR

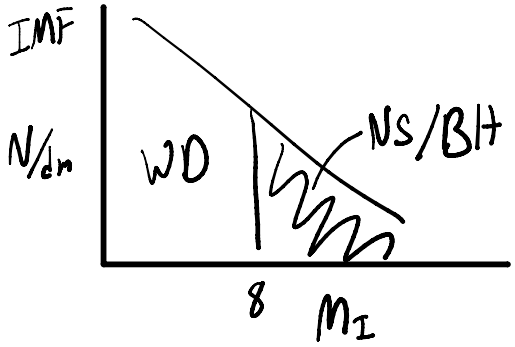
IV stellar mass ...

N massive ★ over ~10 Gyr

SFH = ★ formation history

SFR = ★ formation rate





Simplistic Approach

- how many BHs in galaxy? Depends on ★ SN

$\frac{MW}{1 SN/100 yrs}$ over 10^{10} yr

$N_{BH} = 10^8$ black holes assuming all supernovae from BHs

↳ $n_{BH} \sim \frac{N}{V_{MW}}$ = space density

↳ distance to nearest BH

eRosita = new X-ray telescope

$F_{lim} \Rightarrow L_{Lim}$

Can we observe any stellar mass BHs nearby Bondi Accreting (spherically)?

Minimum Luminosity / Flux?