

(Brown 2015)

Introduction:

- Distribution of HVS & their v can provide existence of a binary MBH
- Stellar motion of HVS is a probe of mass fraction & binary pop. of the galactic center
- Can explain isolated Neutron stars or hostless SN
- Since HVS are pulled by the galaxy give analysis towards shape & orientation of the galaxy's dark matter halo

Physical Understanding:

- 3-body exchange with BH
↳ Host stars of $M > 1 M_{\odot}$ are in binary systems

(Duchêne & Kraus 2013)

- Half of binaries w/ O-star have $T_{orb} < 20$ days
- Within 70 pc;

	Star Type	Prob of binary
(Tokunaga 2014)	G	46%
(Führmann & Chini 2012)	F	60%
(De Rose et al. 2014)	A	70%
(Chini et al. 2012)	O-B ↑ ours	50-80%

- BH of $M > 10^5 M_{\odot}$ are believed to be at center of galaxies

- A BH disrupts a stellar binary at distance r_{bt} & is where gravitational tidal force > binary binding force

$$r_{bt} = a \left(\frac{3M}{m_b} \right)^{1/3}$$

$$r_{bt} \approx 14 \text{ AU} \left(\frac{a}{0.1 \text{ AU}} \right) \left(\frac{M_{\odot}}{m_b} \right)^{1/3} \left(\frac{M}{10^6 M_{\odot}} \right)^{1/3}$$

where a is semi-major axis of binary

- V at binary tidal disruption $V \approx \sqrt{\frac{GM}{r_{bt}}}$
- At disruption ejected stars, $v_{ej} = \sqrt{2}V$ to conserve energy

[Figure 2 shows Schematics \rightarrow Report]

$$v_{ej} = 1370 \left(\frac{a}{0.1 \text{ AU}} \right)^{-1/2} \left(\frac{m_b}{M_\odot} \right)^{1/3} \left(\frac{M}{4 \times 10^6 M_\odot} \right)^{1/6} f_R \text{ km s}^{-1}$$

- f_R is at order of unity \uparrow depends on $r_{peri} \sim 1$
- HVS ejection occurs usually during a binary's first $r_{peri} < r_{bt}$ passage around BH (Antonini et al. 2010, 2011)
- Possibly from BH, stars stripped from tidally disrupting dwarf $\&$ passing through galactic center or SN explosion, also AGN jet...

- SBH encounter not likely for $v_{ej} > 1000 \text{ km s}^{-1}$

\rightarrow Single stars, SBH $\&$ MBH interaction
SBH are remnants of massive stars that migrate due to dynamical friction into region surrounding MBH

\rightarrow Also eject low mass stars w/ highest velocity

- HVS are decelerating over time (further away) \rightarrow largest at $d < 200 \text{ pc}$

\rightarrow Need accurate galactic model

\rightarrow Kenyon et al. (2008) develops a three component, bulge-disk-halo model that fits data

$\rightarrow M_{\text{disk}} = 6 \times 10^9 M_\odot$, disk radial scale = 2.75 kpc
gives V_{circ} coincide w/ Reid et al. 2014

- Size imposes a speed limit on v_{ej}

$$r_{\text{tidal}} = \left(\frac{M}{m_*}\right)^{1/3} r_*$$

if star goes distance $r < r_{\text{tidal}}$ relative to BH it gets crushed.

- Short-lived O HVS can only stem from formation regions

Point of Confusion: Runaway Stars

- Max v_{ej} from SN is $200-300 \text{ km s}^{-1}$
which is sum of SN Kick velocity with orbital velocity of original binary
(Portegies Zwart 2008)

- Dynamical ejections is when runaway ejected from 3 or 4 binary system & has $v \sim 500-600 \text{ km s}^{-1}$ for $4M_{\odot}$ interacting w/ $100M_{\odot}$ binaries

(Graber medze & Gnedin, 2011)

→ However most times it yields merging events

HVS Ejection Rates:

- Binaries with $a < 1 \text{ AU}$ are most likely to stem unbound HVS & most likely to survive in galactic center.

$$\rightarrow v_{ej} \propto \frac{1}{\sqrt{a}}$$

A Brief History of HVS ! Candidate HVS Observations

- Can detect by radial & tangential velocity
- HVS3 moving at 530 km s^{-1} in galactic rest frame
- Stellar atmosphere fits identify it as a $9 M_{\odot}$ MS-star B
 - ↳ Lifetime is \ll flight time from MW ^{product} suggesting LMC origin or stellar evolution of ^{stars} too
 - needs $\sim 1000 \text{ v}_e$; [km s^{-1}]
 - needing unseen MBH / IMBH

Present Observational Understandings of HVS:

- Look at metallicity & compare with nearby regions of LMC
 - ↳ Not definite constant, both observations (Giebran et al. 2010) & theory (Hopkins 2014) shows stars differ in Z at different clusters
- HVS3 sub solar C, N, Mg & Si abundance correlates well w/ LMC or outer Galactic disk origin
- If HVS from disrupted compact binary
 - Stellar rotation, $v \sin i$ should be small $\sim 70 \text{ km s}^{-1}$ due to tidal synchronization of the binaries (Hansen 2007)
 - i Brahm (2010)
- Perets (2009) argued HVS3 has MW origin
 - However proper motion data needs to be more precise to say this for certainty & since my pps suggest LMC origin
 - ↳ Irrgang 2013
 - Erkal 2018
 - Portegieszwart 2007

Future Prospects:

- HVS can map matter & dark matter mass distribution
 - ↳ V & trajectories provide mass constraints (Gnedin et al. 2005)
 - ↳ 3D motion constrain shape & orientation of galaxies mass distribution (Gnedin et al. 2005)
 - ↳ If galactic potential is triaxial, HVS motion differ from radial
 - ↳ A prediction of CDM models
- Based on observations of HVS & S Stars of MW, central black hole may have grown 2-4x larger in last 5-10 Gyr due to binary disruption (Bramley et al. 2012)
 - ↳ Ejection rate \propto mass growth