Hans Bonnell, Bate & Zinnecker 1998; Bally & Zinnecker 2005

Zinnecker 1982
Zinnecker 1984

Ochsendorf, Zinnecker et al 2017

Leinert, Zinnecker et al 1993

Andersen, Zinnecker et al 2009

Zinnecker et al 1998

Reipurth & Zinnecker 1993
Figure 2. The evolution of the mass spectrum, $\xi = dN/d \log M$, of gravitating point masses for an accretion rate $\dot{M} = \alpha M^2$ (a narrow symmetric distribution evolves into a broad asymmetric distribution).

10. A spherical inflow of gas onto a point mass $M_0$ undergoes a sonic transition at a radius $R_B = GM/2c_s^2$, where $c_s$ is the sound speed of an isothermal medium of density $\rho$. Write down an expression for the accretion rate onto the object and hence derive an expression for $M(t)$, the mass of the object at time $t$, if it grows by accretion from an initial mass of $M(0) = M_0$.

A population of stars grows in this way from a range of initial $M_0$ values. Derive an an expression for $dM/dM_0$ at given time and express your answer in terms of $M_0$ and $M$. If the distribution of masses is initially flat over a small range of $M_0$, derive an expression for the form of the IMF that is expected following accretional growth and comment on your answer.
Simulations generate Salpeter like tail in regimes where stars acquire most of mass by accretion

Maschberger et al 2014

...yet apparently accretion rate does not scale quadratically with $M_*$ in the simulations!

M14 argued for a complex combination of stochastic accretion and spread in initial masses and growth times
Back to simplicity?

Ballesteros-Paredes et al 2016
What about turbulence and B fields?

• See e.g. Krumholz et al 2005, Lee et al 2014, Burleigh et al 2017 for idealised Bondi Hoyle experiments in turbulent magnetised media.

Increasing B field

Suppresses accretion cf pure Bondi Hoyle

Quadratic dependence on M preserved
Can the idea extend to star cluster formation?

See Kuznetsova, Hartmann & Burkert 2017 for simulations of sub-virial cluster formation
What about the massive stars?

Formation of massive stars by stellar collisions following accretion driven contraction of cluster cores: Bonnell, Bate & Zinnecker 1998
\begin{itemize}
\item $T_M > T_{2r}$ \Rightarrow \text{max. density set by stellar dynamical effects}

\item $T_M < T_{\text{dyn}}$ \Rightarrow \text{radius shrinks by factor } \sim 2

\item $T_{\text{dyn}} < T_M$ \Rightarrow \text{contracts adiabatically } R \sim M^{-3}, \rho \sim M^{10}
\end{itemize}

\Rightarrow \text{expect accretion induced collisions to be important at high } N \ldots

\text{No. collisions } \sim M_{\dot{m}}^{2/3} N^{5/3}

\text{Clarke & Bonnell 2008}
Where are accretion induced core collapse + stellar collisions likely to be important?

- Arches? Not in past... Baumgardt & Klessen 2011; Moeckel & Clarke 2011
- Primordial clusters: promising route to IMBHs
  Reinoso et al 2018; Boekholt et al 2018
`What about the binaries?`

- Taurus binary data established central role for multiplicity in star formation

Leinert, Zinnecker et al 1993
Now is a golden time for young binary characterisation

- The ALMA opportunity: interest in circumbinary disc structure re-ignited by circumbinary planets

  Takahuwa et al 2017

- The GAIA opportunity: kinematic substructure in star forming regions

  Kinematics and extended structure can be modeled as disintegrating quadruple:
  Winter et al 2018

Reipurth & Zinnecker 1993

Howard et al 2013
There is much, much more..

Including...

THE NUCLEI OF NUCLEATED DWARF ELLIPTICAL GALAXIES - ARE THEY GLOBULAR CLUSTERS?

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