The Mass function

November 20, 2006

Definition

- Linked to the formation scenarii
- Mass/light ratio of stars
- Present-day mass function Ξ vs. IMF ξ, b is the S.F.History:

$$\Xi(m) = \xi(m)\frac{1}{\tau_G}\begin{cases}\int_{\tau_G-\tau(m)}^{\tau_G} b(t)dt & , \quad \tau(m) < \tau_G, \\ \int_0^{\tau_G} b(t)\,dt & , \quad \tau(m) \geq \tau_G,\end{cases}$$

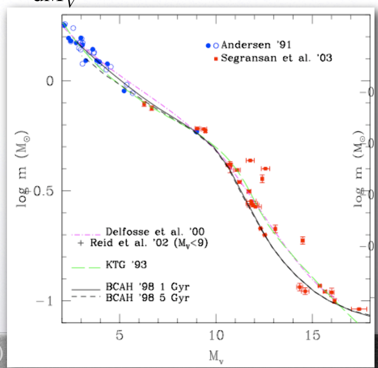
- Mass loss, negligible (except very massive stars)

Derivation

- Observations of the LF: $F(M_V) = \frac{dN}{dM_V}$
- Conversion to the MF:

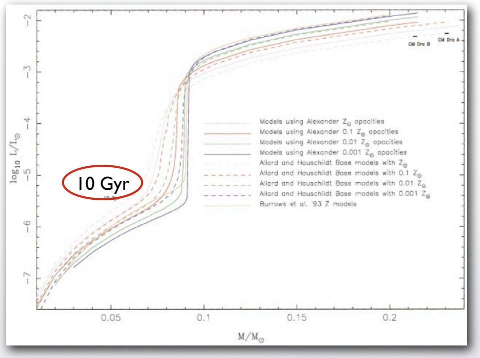
$$f(m) \equiv \frac{dN}{dm} = F(M_V)\frac{dM_V}{dm}$$

- Depends on Z, age & spin (massive stars)



Chabrier (2005)

BD specifics



Burrows et al. (2001)

Observations

- Biases (see *New light...*, §8.4):
  - Malmquist: magnitude
  - Lutz-Kelker: distance
  - Eddington: detection

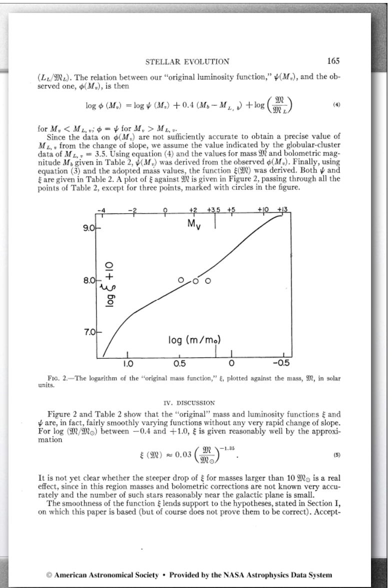
  } can be simulated, provided errors are known
- binarity: can be simulated, provided binary %ages are known

Stellar mass function

- Salpeter (1955):

$$f(m) \propto m^{-\alpha}, \alpha = 2.35$$

$$\frac{\mathrm{d}N}{\mathrm{d}\log m} \propto m^{-x}, x = 1.35 = \alpha - 1$$



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$(L_L/\mathfrak{M}_L)$. The relation between our "original luminosity function," $\psi(M_v)$, and the observed one, $\phi(M_v)$, is then

$$\log \phi(M_v) = \log \psi(M_v) + 0.4 (M_b - M_{L,b}) + \log\left(\frac{\mathfrak{M}}{\mathfrak{M}_L}\right) \quad (4)$$

for $M_v < M_{L,v}$; $\phi = \psi$ for $M_v > M_{L,v}$.

Since the data on $\phi(M_v)$ are not sufficiently accurate to obtain a precise value of $M_{L,v}$ from the change of slope, we assume the value indicated by the globular-cluster data of $M_{L,v} = 3.5$. Using equation (4) and the values for mass $\mathfrak{M}$ and bolometric magnitude M_b given in Table 2, $\psi(M_v)$ was derived from the observed $\phi(M_v)$. Finally, using equation (3) and the adopted mass values, the function $\xi(\mathfrak{M})$ was derived. Both ψ and ξ are given in Table 2. A plot of ξ against $\mathfrak{M}$ is given in Figure 2, passing through all the points of Table 2, except for three points, marked with circles in the figure.

FIG. 2.—The logarithm of the "original mass function," ξ, plotted against the mass, $\mathfrak{M}$, in solar units.

IV. DISCUSSION

Figure 2 and Table 2 show that the "original" mass and luminosity functions ξ and ψ are, in fact, fairly smoothly varying functions without any very rapid change of slope. For $\log(\mathfrak{M}/\mathfrak{M}_\odot)$ between -0.4 and $+1.0$, ξ is given reasonably well by the approximation

$$\xi(\mathfrak{M}) \approx 0.03 \left(\frac{\mathfrak{M}}{\mathfrak{M}_\odot}\right)^{-1.35}. \quad (5)$$

It is not yet clear whether the steeper drop of ξ for masses larger than $10\,\mathfrak{M}_\odot$ is a real effect, since in this region masses and bolometric corrections are not known very accurately and the number of such stars reasonably near the galactic plane is small.

The smoothness of the function ξ lends support to the hypotheses, stated in Section I, on which this paper is based (but of course does not prove them to be correct). Accept-

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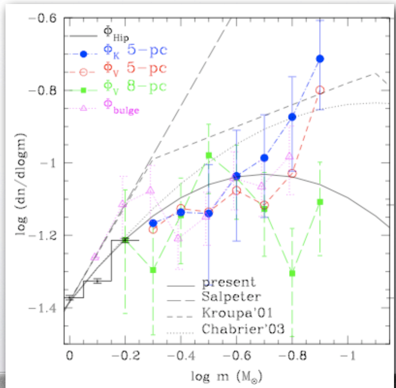
Salpeter (1955)

Field stellar IMF

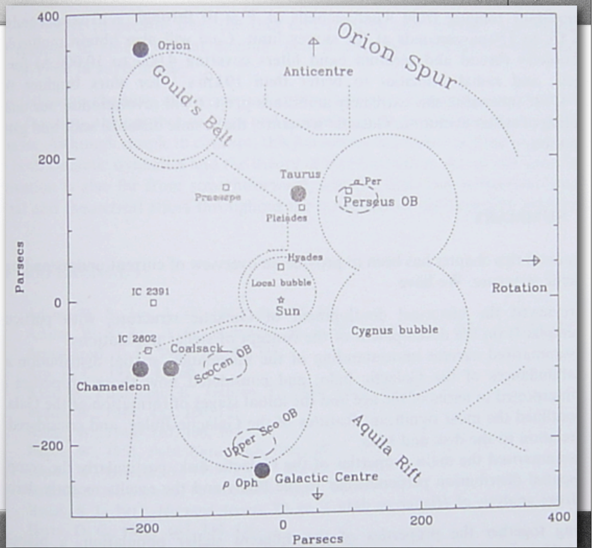


Chabrier (2005)

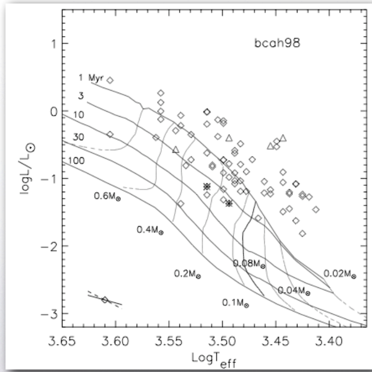
Cluster IMF

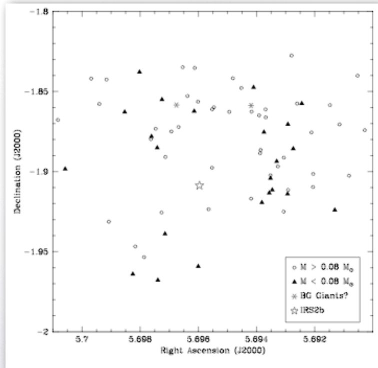
- Various targets:
  - open clusters: wide, high contamination (low extinction)
  - young clusters: compact, higher extinction
  - age: young vs. old (fainter, evaporation). Internal dispersion?
- Issues:
  - evaporation of lower mass members (BD ejection scenario)
  - interaction with the Galactic disk
  - age and distance determination

Cluster locations



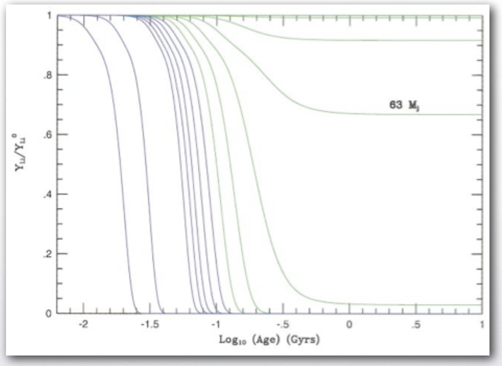
Example: NGC 2024





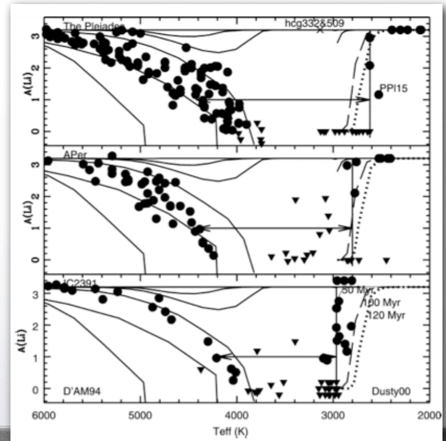
Levine et al. (2006)

Comments on age



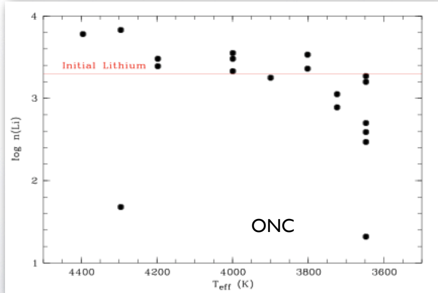
Burrows et al. (2001)

Lithium age determination



Barrado y Navascues (2005)

Lithium age determination

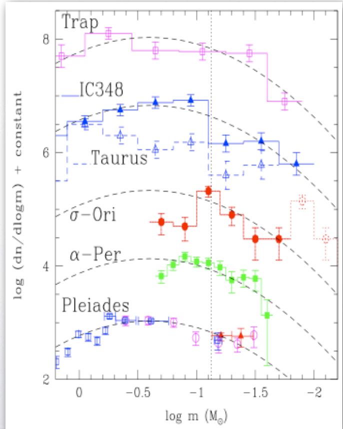


Palla & Randich (2005)

Issues

- Contamination by field stars:
  - proper motion discrimination
  - spectroscopic young indicators:
    - accretion: Hα, UV excess
    - coronal activity: X emission,
    - circum(sub)stellar disks: IR excess
- Crowding effects for dense clusters

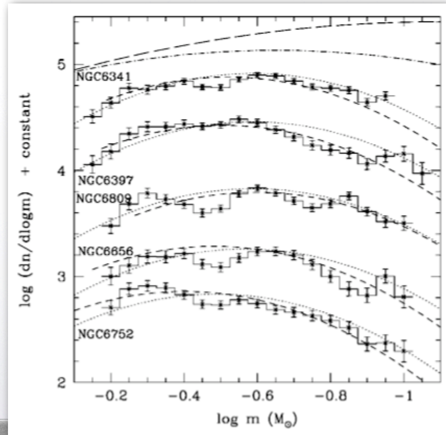
Results



Chabrier (2005)

Globular clusters

- Old: dynamical correction
- Dense: crowding correction
- Binarity correction



Chabrier (2003)

Field IMF

- Magnitude-limited sample
- $1/V_{max}$ method
- Check efficiency: $<V/V_{max}>=1/2$

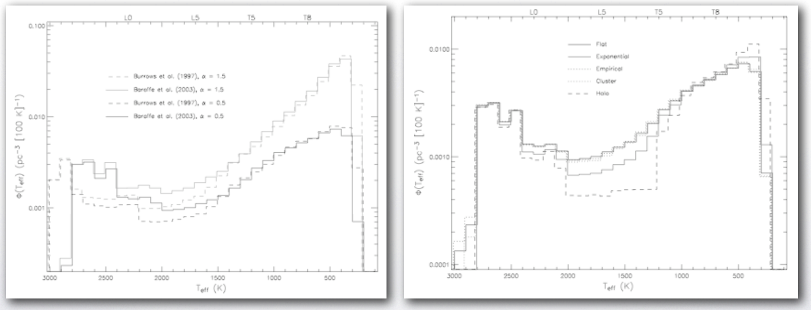
Field IMF

- Magnitude-limited sample
- Age-mass degeneracy: work around: simulations
  - e.g. Burgasser (2004)

Fundamental Distributions for Monte Carlo Simulations

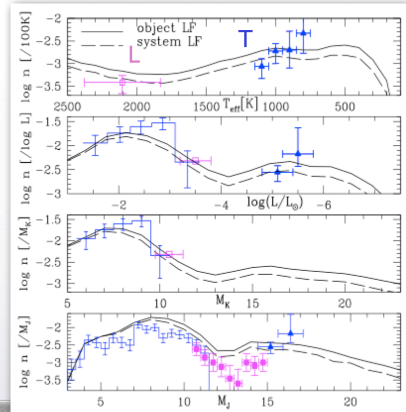
Distribution (1)	Form (2)	Parameters (3)
$\Psi(M)$	$\propto M^{-\alpha}$	$\alpha = 0.0, 0.5, 1.0, 1.5, 2.0$
	$\propto e^{-(\log M - \log M_c)^2/2\sigma^2}$	$M_c = 0.1\ M_\odot$, $\sigma = 0.627$[a]
$P(t) = b(T_0 - t)$	$\propto$constant	
	$\propto e^{-(T_0-t)/\tau_g}$	$T_0 = 10$ Gyr, $\tau_g = 5$ Gyr
	Empirical[b]	
	$\propto \sum_{i=1}^{N_{cl}} e^{-\lvert(T_0-t)-t_0^i\rvert^2/2\tau_{cl}^2}$	$N_{cl} = 50$, $\tau_{cl} = 10$ Myr
	$\propto$constant $t \leq 1$ Gyr	
$P(Z)$	$\propto$constant	$Z = Z_\odot$
$P(q)$	$\propto$constant	
	$\propto e^{(q-1)/q_c}$	$q_c = 0.26$[c]
	From MF[d]	$\alpha = 0.5$

Age-mass degeneracy solution



Burgasser (2004)

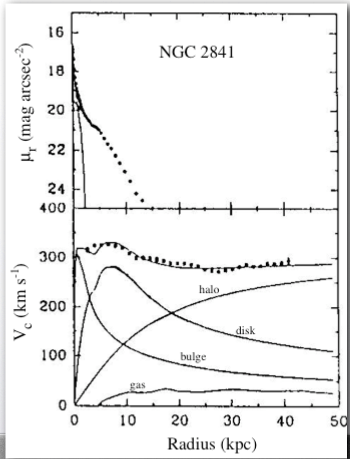
Results



Chabrier (2005)

BD and Galactic dark matter

1. Flat rotation curves of spiral galaxies (MW,...)
2. Baryonic composition:
   1. $\Omega_{Baryons}$=4.7±0.6% (CMB)
   2. $\Omega_{visible}$ =0.4–0.7%



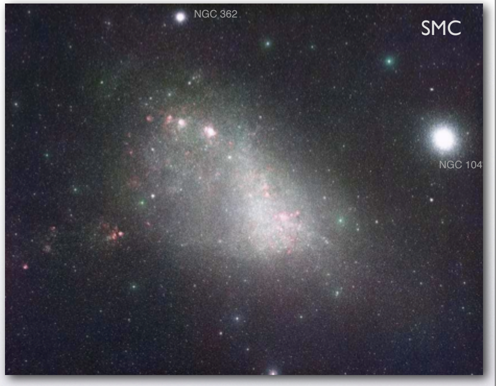
Begeman (1987)

Why a halo?

- No dark matter in the disk
  - e.g. Flynn & Fuchs (1994), Crézé et al. (1998, Hipparcos)
- Recently: Halo streams

Microlensing projects

- Crowded fields
- Large CCD mosaics
- Resolved populations (LMC, SMC) or not (M31)

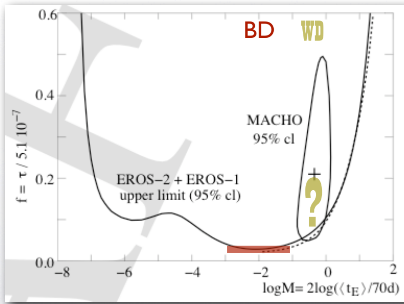


Malin ©AAO/ROE

Microlensing results

<3% contribution
to the dark matter over the whole BD regime

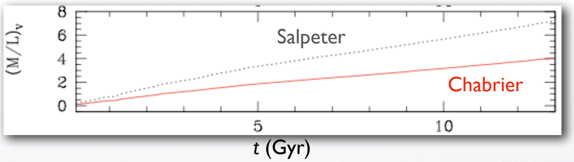
controversy about the WD-mass-like contribution



Tisserand et al. (submitted)

Summary

- Preliminary results:
  - n_{BD}/n_*=1/3 (Chabrier, 03), integrating over poorly-observed mass ranges
  - mass/light ratio:



  - BD contribution to the disk: 2%, to the spheroid: 3%
- Results awaiting confirmation with larger samples

Chabrier (2005)

Next lecture

- ARI, Monday, November 27th, 15:15
- Formation of brown dwarfs:
  - theory: core collapse, ejection,...
  - predictions and observations
- Readings:
  - *New light on dark stars:* §3.6, §7.6