Magnetic Fields in Globular Clusters

Anna Scaife

UNIVERSITY OF Southampton

Globular Clusters

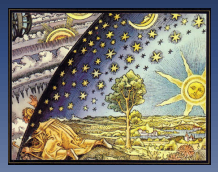
- Gravitationally bound spherical associations of stars
- High Galactic latitude
- Old stars
- Pass through the Galactic Plane every $\sim 10^8$ years

Globular Clusters

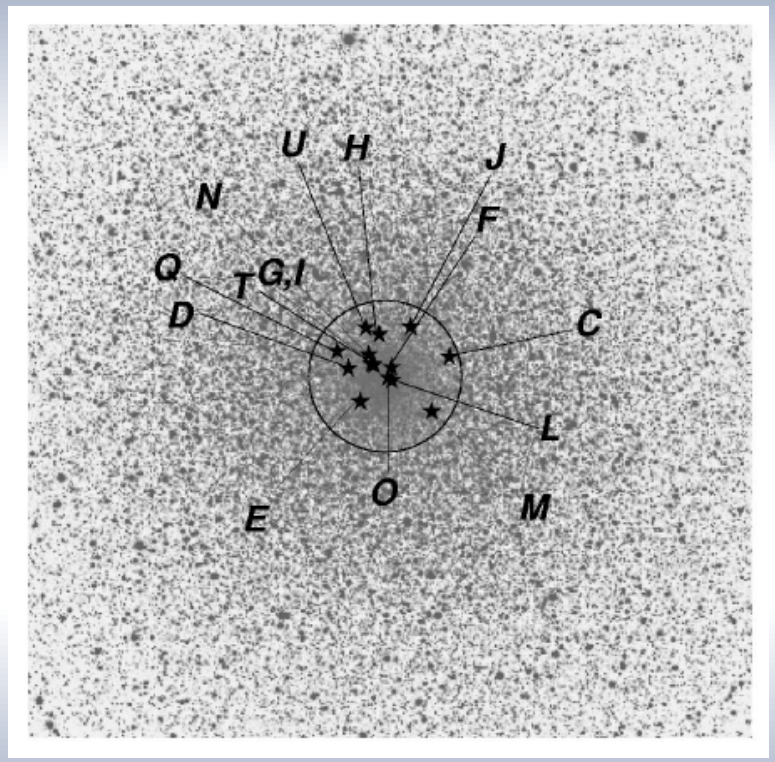
- Full of hot stars
- UV flux from stars ionizes intra-cluster medium
- ICM comes from stellar mass loss
- Evolved stars have highly magnetized winds

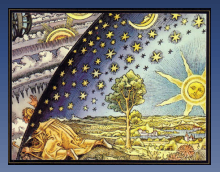
Globular Clusters

- Are there magnetic fields interspersing the ICM in globular clusters?
- Have they been ejected by stellar winds?
- Are they a relic of passage through the Galactic plane?



Full of pulsars

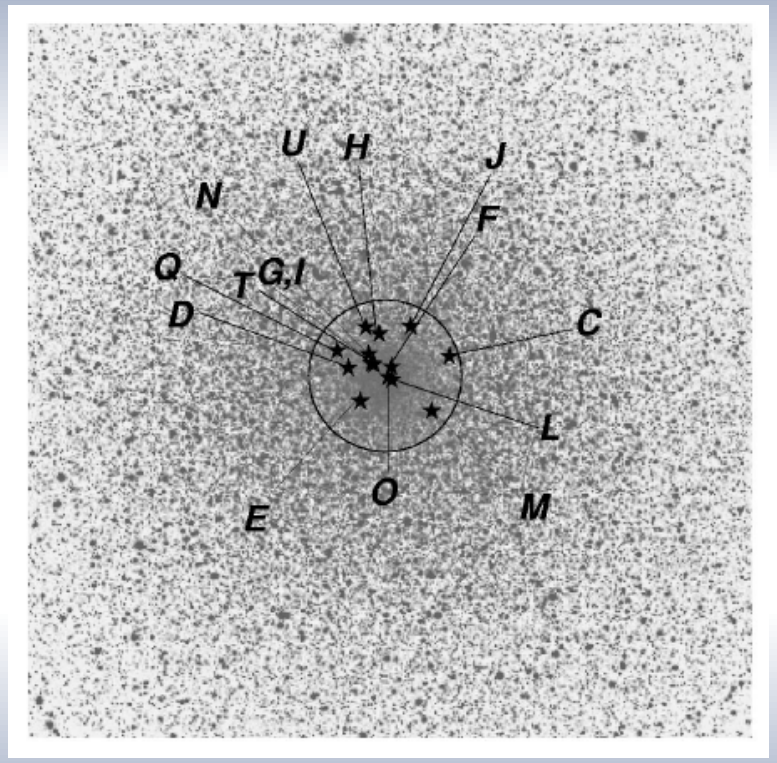




Dispersion Measure

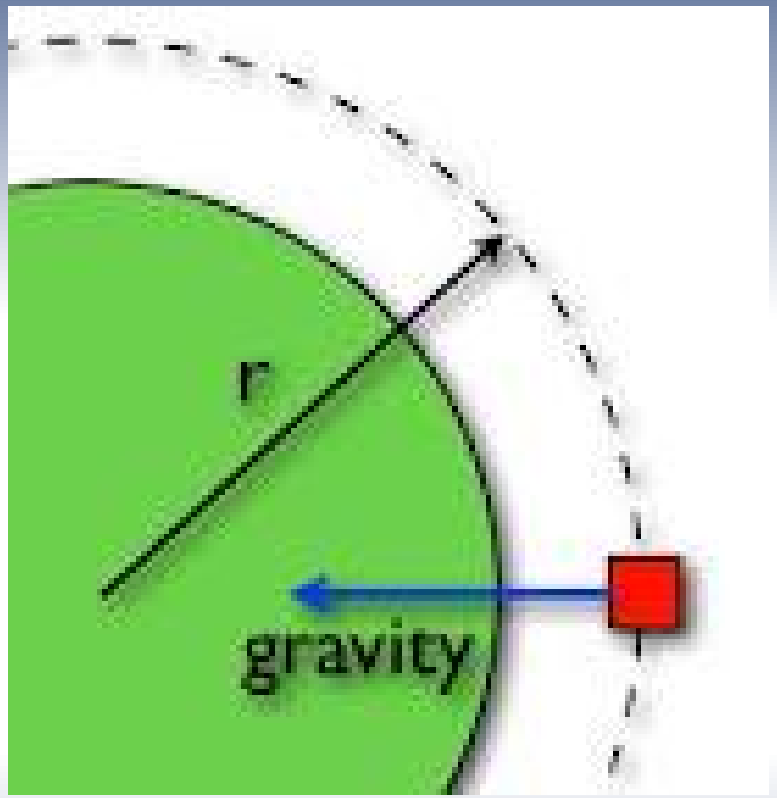
The dispersion measure is defined as:

$$DM = \int_{\text{los}} n_{\text{e}} \mathrm{d}\ell$$

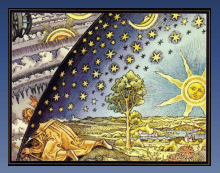


Precision timing of pulsars

- Globular clusters are filled with pulsars
- Each pulsar has a pulse period P
- and also a derivative of that period $\dot{P}$.
- Although there is an intrinsic derivative $\dot{P}_{\rm int}$, this derivative is dominated by the line-of-sight component of the gravitational acceleration, a, towards the centre of the cluster.



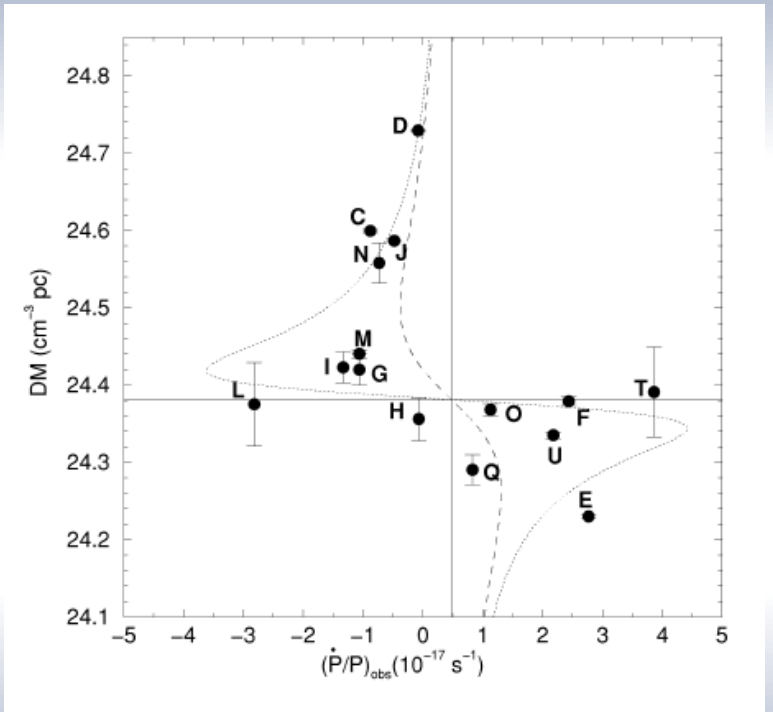
- $\dot{P}/P = a/c$
- $(\dot{P}/P)_{\rm obs}$ is a tracer of the cluster gravitational field.

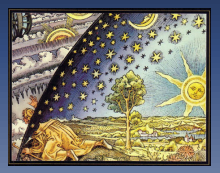


Line-of-sight

The dispersion measure is defined as:

$$DM = \int_{\mathrm{los}} n_{\mathrm{e}} \mathrm{d}\ell$$

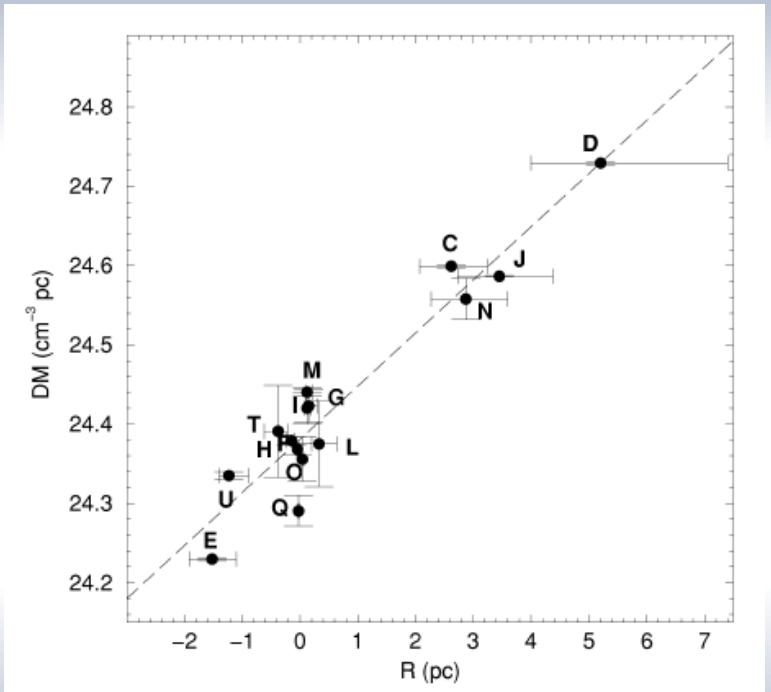




Line-of-sight

Can calculate the l.o.s. distance of each pulsar assuming:

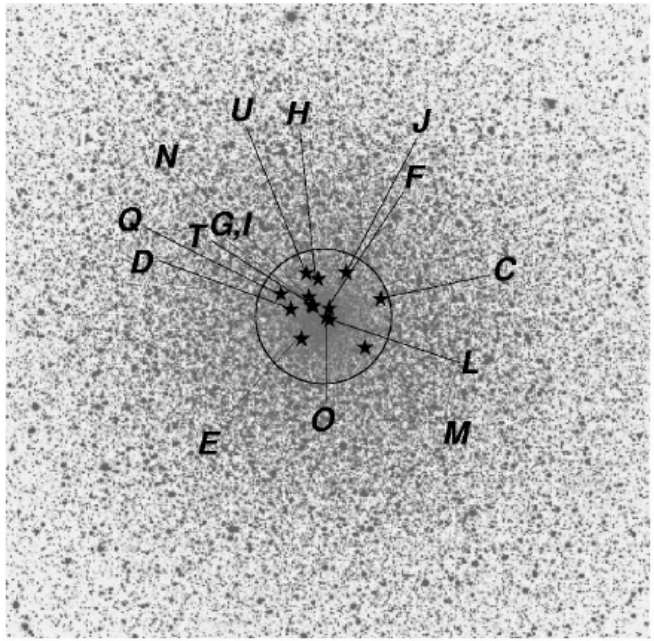
$$a/c = (\dot{P}/P)_{\rm obs} - <(\dot{P}/P)_{\rm int}>$$



Determining the electron density

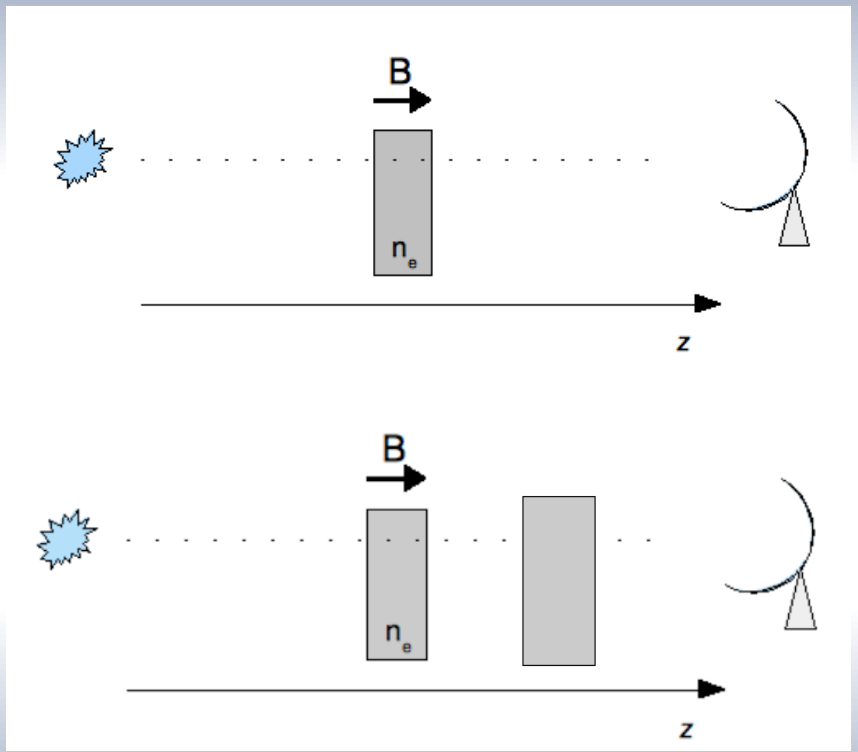
Once the distance, R, has been calculated the observed DM for each pulsar can be calculated:

$$DM_i = DM_c + n_e R_i (\dot{P}/P)_{obs} - < (\dot{P}/P)_{int} >\}$$

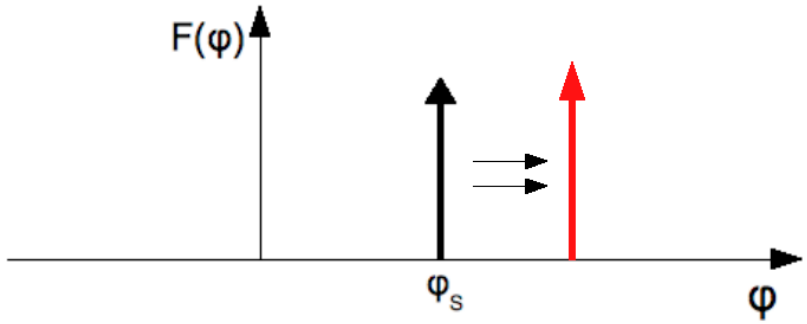


$n_e = 0.067 \pm 0.013\,\mathrm{cm}^3$ (100 x ISM)

Determining *B*-fields

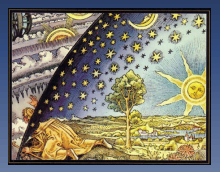


$$\phi = 0.81 \int_{\mathrm{pc}} \frac{n_e}{\mathrm{cm}^{-3}} \frac{B_{||}}{\mu\mathrm{G}} \mathrm{d}z \,\mathrm{rad}\,\mathrm{m}^{-2}$$



$$RM = 0.81 \int_{\mathrm{los}} n_{\mathrm{e}} B \cdot \mathrm{d}z$$

$$< B_{||} >= 1.232 \frac{RM}{DM}\ \mu\mathrm{G}$$



LOFAR plans

Test target: **M15** (NGC 7078)

- Well-studied
- $\ell = 65.0;\ b = -27.3$
- $< B_{||} >= 1.232 \frac{RM}{DM}\ \mu$G
  $\rightarrow\ RM = B_{||} * DM/1.232$
- $RM \approx 4 - 5\,\mathrm{rad\,m^{-2}}$