Energy functions of fast radio bursts derived from the first CHIME/FRB catalogue

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(MN, June 2022)

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Introduction

- **what is the FRBs?**

millisecond-duration,radio waves,randomly occur in the sky

- **FRB classification**

Two types of FRBs:Non-repeating FRBs Repeating FRBs

- **FRBs origins are unknown**

White dwarf;Old neutron star ;black hole (BH);Magnetar;Young pulsar and so on.

Introduction

- **Origin: How can we identify the progenitor?**

➢ **Localization**

- localized FRB 200428 at a Galactic magnetar **Bochenek et l.2020**
- FRB 20200120E --> globular cluster (old stellar system). **Tendulkar et al. 2021**
- FRB 20180916B --> star-forming region. **Kirsten et al. 2021**

Problem: no more 'direct' confirmation of the FRB progenitor

Introduction

- **Origin: How can we identify the progenitor?**

➢ **focus on the history of FRBs**

➢ Old objects ∝ stellar mass： White dwarf, Old neutron star, Old stellar-mass, black hole (BH).

➢ Young objects ∝ star formation： Magnetar, Young pulsar, Super massive BH, Supernova remnant.

→ The number density of FRB sources vs the density of possible ancestors

DATA ANALYSIS

- **Sample:** 176 FRB(164 nonrepeating FRBs and 12 repeating FRBs) from CHIME catalogue.**The CHIME/FRB Collaboration et al. (2021)**

➢The selected sample satisfies all of the following criteria.

- ➢bonsai_snr > 10
- ➢$DM_{obs} > 1.5 \times \max(DM_{NE2001}, DN_{YMW16})$
- ➢not detected in far side-lobes
- ➢$\log \tau_{scat} < 0.8$(ms)
- ➢excluded_flag = 0
- ➢the first detected burst if the FRB source is a repeater
- ➢$\log F_v > 0.5$ (Jy ms)

DATA ANALYSIS

●Selection functions

$$P(\varphi) = Pobs(\varphi) \times s(\varphi)^{-1} \quad \varphi = DM, \tau_{scat}, w_{\mathrm{int}}, F_{v}$$

Where $P(\varphi)$and $P_{obs}(\varphi)$are the intrinsic and observed distributions,respectively.

$s(\varphi)$ is the selection function as a function. **For details, see section 2.1.**

$$W_{scale} \sum_{i=1}^{n} w_i(\mathrm{DM}) w_i\left(\tau_{scat}\right) w_i\left(w_{int}\right) w_i\left(F_{\nu}\right) = \frac{84{,}697}{39{,}638} \times 176$$

DATA ANALYSIS

- Number density of each FRB source

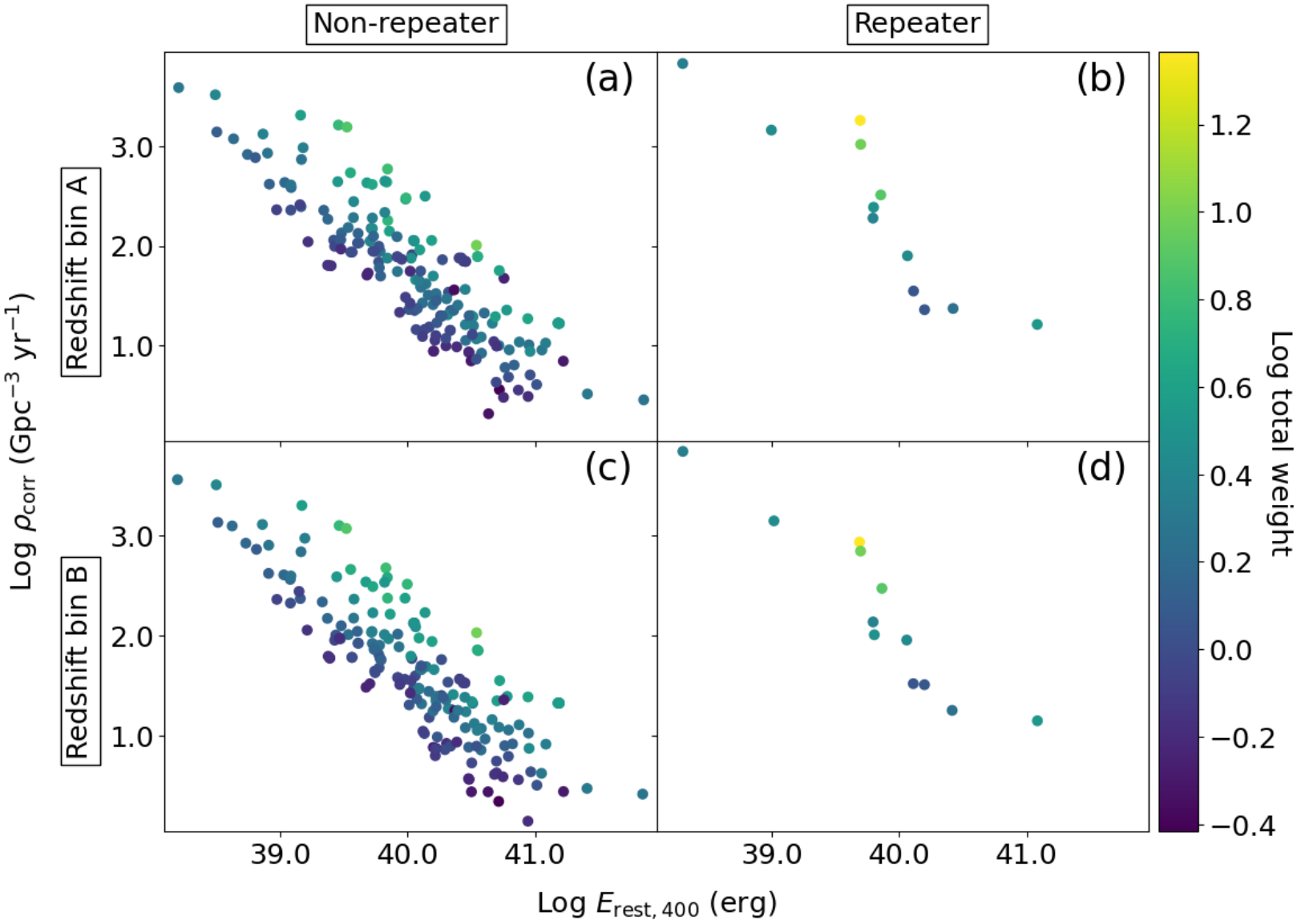
$$\rho_{\text{uncorr}}\ \left(E_{\text{rest},400}\right) = \frac{1+z_{\text{FRB}}}{V_{\text{max},4\pi}\Omega_{\text{sky}}t_{\text{obs}}}$$

$$\rho_{\text{corr}}\ \left(E_{\text{rest},400}\right) = \rho_{\text{uncorr}}\, W_{\text{scale}}\, w(\text{DM}) w\left(\tau_{\text{scat}}\right) w\left(w_{\text{int}}\right) w\left(F_{\nu}\right)$$

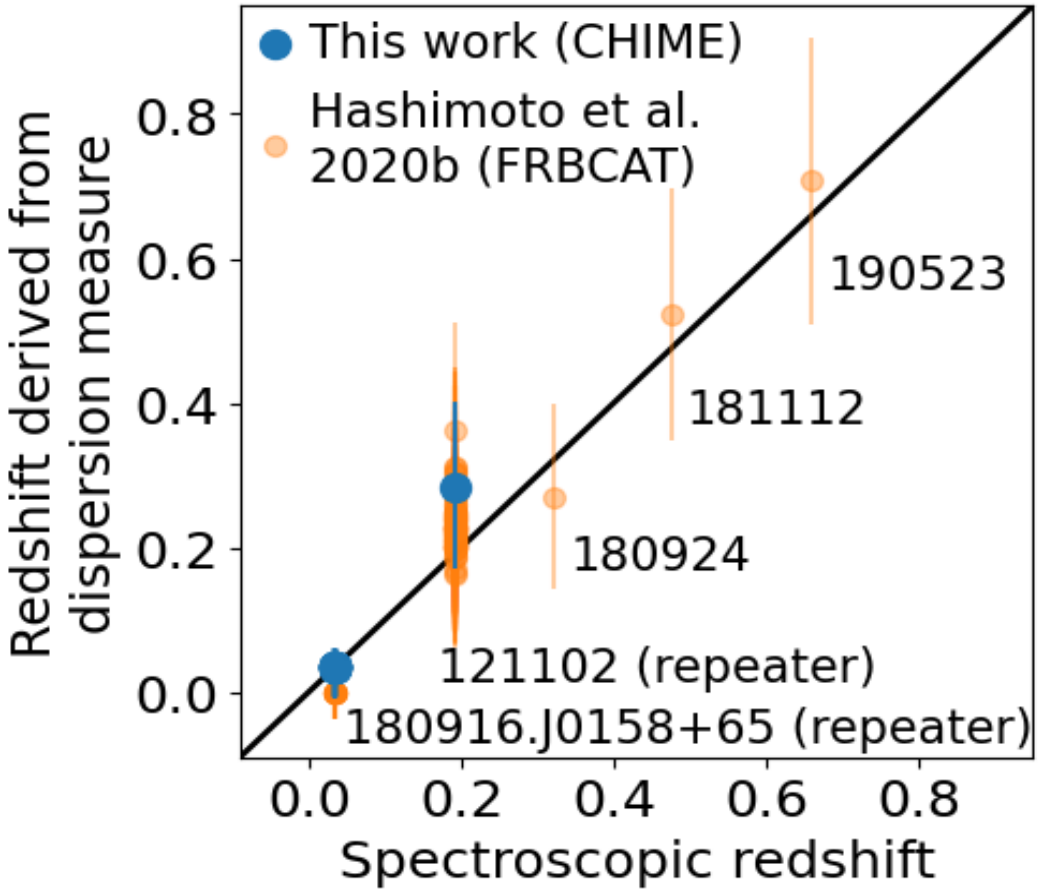
- energy functions

$$\phi\left(z_{\text{median}}, E_{\text{rest},400,j}\right) = \sum \rho_{\text{corr}}\ \left(E_{\text{rest},400,j,k}\right) / \Delta \log E_{\text{rest},400}$$

total weights



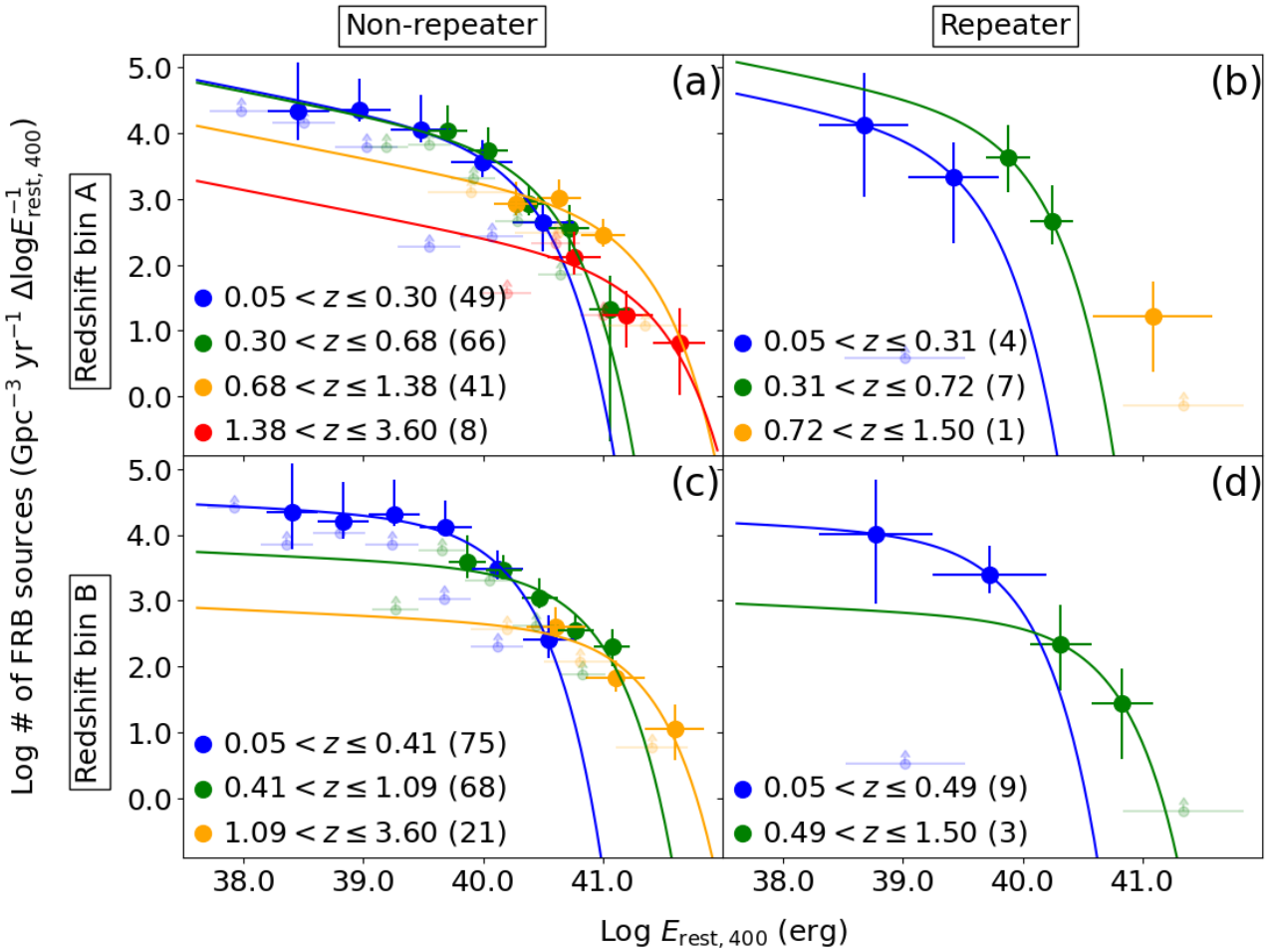
Result:



- The redshift derived from the dispersion measurement is consistent with the spectral redshift

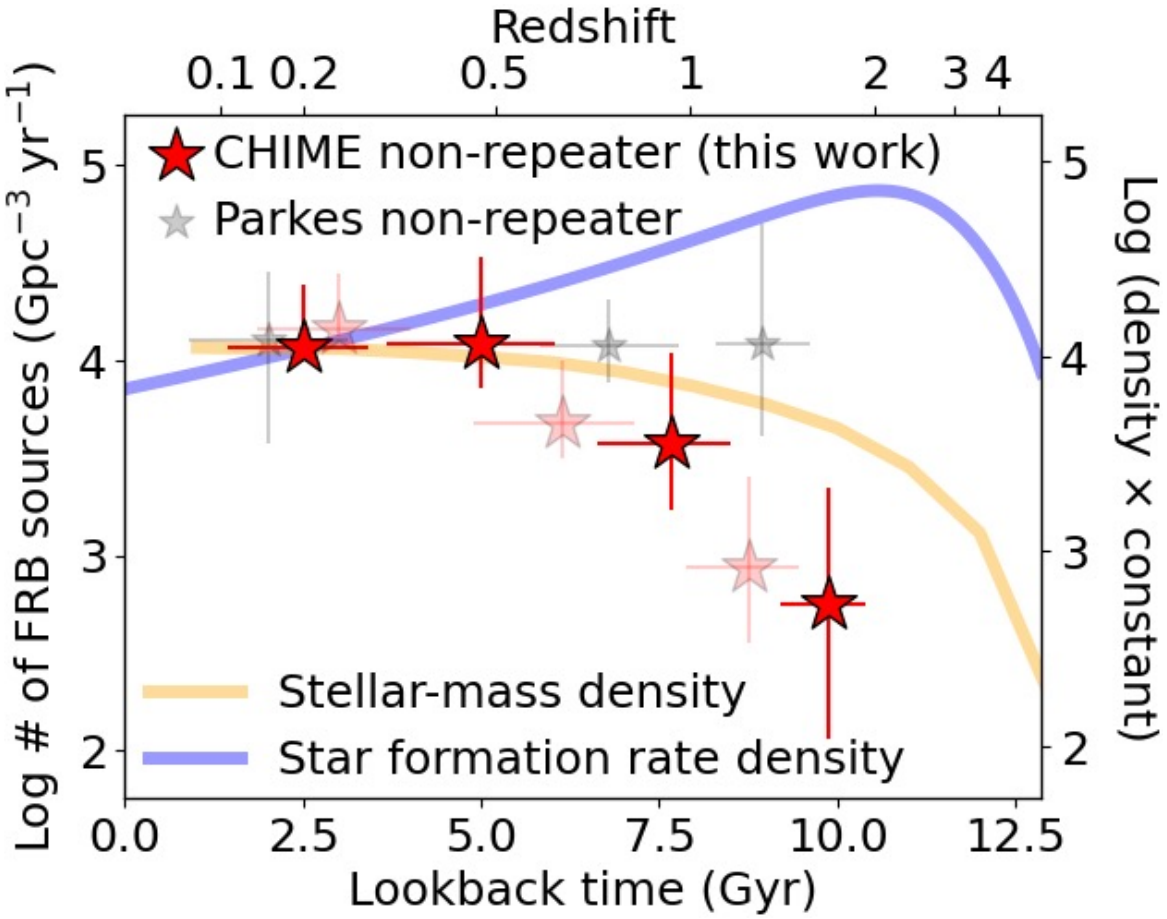
Result: energy function

$$\phi(\log E)\mathrm{d}\log E = \phi^* \left(\frac{E}{E^*}\right)^{\alpha+1} \exp\left(-\frac{E}{E^*}\right)\mathrm{d}\log E$$



- lowest-z bin for fitting, due to the lack of data points at lower energies.
- Non-repeatingFRBs show clear decreasing trends at $z \leq 1$
- Repeating FRBs:The number of data points is too small.

Result: The volumetric rate



- Before z<2, the volume rate of non-repeating FRBs decreases with increasing redshift.
- The observed decline aligns with the stellar mass density evolution but not with the stellar formation rate trends.
- Old stellar populations are the origin of most non-repeating FRBs

Summary

- The energy function and volume fraction of non-repeating FRBs show a downward trend, with higher and higher redshift values.
- The “old-age population” is the origin of most non-repetitive FRBs
- Cautions

  - high scattering
  - faint bursts
  - sample contamination of repeating FRB sources

missed by CHIME

Thanks for your listening!

Please feel free to contact us:

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