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[A Local Universe Host for the Repeating Fast Radio Burst FRB 20181030A](https://arxiv.org/abs/2108.12122)

> 重复FRB 20181030A的一个本地宇宙宿主星系

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▶ details

We report on the host association of FRB 20181030A, a repeating fast radio burst (FRB) with a low dispersion measure (DM, 103.5 pc cm−3) discovered by CHIME/FRB Collaboration et al. (2019a). Using baseband voltage data saved for its repeat bursts, we localize the FRB to a sky area of 5.3 sq. arcmin (90% confidence). Within the FRB localization region, we identify NGC 3252 as the most promising host, with an estimated chance coincidence probability < 2.5×10^−3. Moreover, we do not find any other galaxy with $M_r <$ −15 AB mag within the localization region to the maximum estimated FRB redshift of 0.05. This rules out a dwarf host 5 times less luminous than any FRB host discovered to date. NGC 3252 is a star-forming spiral galaxy, and at a distance of ≈ 20 Mpc, it is one of the closest FRB hosts discovered thus far. From our archival radio data search, we estimate a 3σ upper limit on the luminosity of a persistent compact radio source (source size < 0.3 kpc at 20 Mpc) at 3 GHz to be $2 \times 10^{26} ergs^{-1} Hz^{-1}$, at least 1500 times smaller than that of the FRB 20121102A persistent radio source. We also argue that a population of young millisecond magnetars alone cannot explain the observed volumetric rate of repeating FRBs. Finally, FRB 20181030A is a promising source for constraining FRB emission models due to its proximity, and we strongly encourage its multi-wavelength follow-up.

- 文章寻找了FRB 20181030A(CHIME/FRB发现)的宿主星系, 使用其重复爆发的baseband voltage data, 将FRB的位置定在了5.3平方角分的范围内.
- 在这片区域内, 作者认为NGC 3252是最可靠的宿主星系.
- 另外, 作者没有在此区域找到红移在0.05以内且亮度M_r小于-15等的其它星系, 这排除了比目前的FRB宿主星系亮度低5倍的矮星系是宿主星系的情况
- NGC 3252是一个恒星形成的螺旋星系, 距离在20Mpc左右, 是目前位置距离最近的FRB宿主星系之一.
- 作者根据数据估计了一个持续的致密射电源的3sigma上限光度为$2 \times 10^{26} ergs^{-1} Hz^{-1}$ (20Mpc, 源尺寸< 0.3 kpc, 3GHz), 至少比FRB20121102A这个持续爆小1500倍.
- 作者还认为单纯用年轻的毫秒磁星不足以解释观测到的重复FRB的volumetric rate(单位: $Gpc^{-3} yr^{-1}$).
- 最后, 由于距离近, FRB20181030A是一个有希望较好限制FRB辐射模型的源, 作者鼓励多波段的后随观测.

Q&A:

- baseband voltage data? 基带电压数据?, 如何定位?
- 作者主要是根据什么来判断可能的宿主星系? 拍摄矮星系的原因是亮度低还是红移大于0.05? 为什么以红移0.05为标准?
    - 在去除银河系对DM值的影响后, 这个FRB的DM-excess是30-40之间. 根据Macquart的等人2020年nature文章的公式(如下), 估计了红移大概在0.03-0.04(忽略宿主星系的DM贡献).

Adopting our cosmological paradigm of a flat universe with matter and dark energy, the average value of DM_{cosmic} to redshift z_{FRB} is:

$$\langle \mathrm{DM_{cosmic}} \rangle = \int_0^{z_{\mathrm{FRB}}} \frac{c\bar{n}_e(z)\mathrm{d}z}{H_0(1+z)^2\sqrt{\Omega_m(1+z)^3+\Omega_\Lambda}} \quad (2)$$

with mean density $\bar{n}_e = f_d \rho_b(z) m_p^{-1}(1 - Y_{He}/2)$, where m_p is the proton mass, $Y_{He} = 0.25$ is the mass fraction of helium, assumed doubly ionized in this gas, $f_d(z)$ is the fraction of cosmic baryons in diffuse ionized gas (this accounts for dense baryonic phases, for example, stars and neutral gas; see Methods), $\rho_b(z) = \Omega_b \rho_{c,0}(1+z)^3$, and Ω_m and Ω_Λ are the matter and dark energy densities today in units of $\rho_{c,0} = 3H_0^2/8\pi G$ where we parameterize Hubble's constant H_0 in terms of the dimensionless $h_{70} = H_0/(70\ \mathrm{km\ s^{-1}\ Mpc^{-1}})$.

$$\mathrm{DM_{FRB}}(z) = \mathrm{DM_{MW,ISM}} + \mathrm{DM_{MW,halo}} + \mathrm{DM_{cosmic}}(z) + \mathrm{DM_{host}}(z) \quad (1)$$

with $DM_{MW,ISM}$ the contribution from our Galactic ISM, $DM_{MW,halo}$ the contribution from our Galactic halo[13], DM_{host} the contribution from the host galaxy including its halo and any gas local to the event, and DM_{cosmic} the contribution from all other extragalactic gas. Only DM_{cosmic}, determined by its path length through the IGM and the increase in baryon density with look-back time, is expected to have a strong redshift dependence, although DM_{host} is weighted by $(1+z_{FRB})^{-1}$ and may correlate with age, for example, if host galaxies have systematically lower mass at earlier times.

    - 0.05是作者通过MCMC模拟估计的这个FRB的最大红移
    - 如果把迄今发现的最暗的FRB宿主星系($M_r = -17$ AB mag 放在z=0.05的位置, 再假设它是一个表面亮度达到DESI Legacy Imaging Survey极限(~ 26 mag arcsec^-2)的low surface brightness galaxy, 这在DESI数据中的星等大概小于等于22等(应该大概相当于$M_r = -15$), 这相当于能够探测到比目前的FRB宿主星系($M_r = -15$ AB mag)亮度低5倍的矮星系. 作者据此挑了7个$m_r < 22$ AB mag, 且位置符合的7个星系.

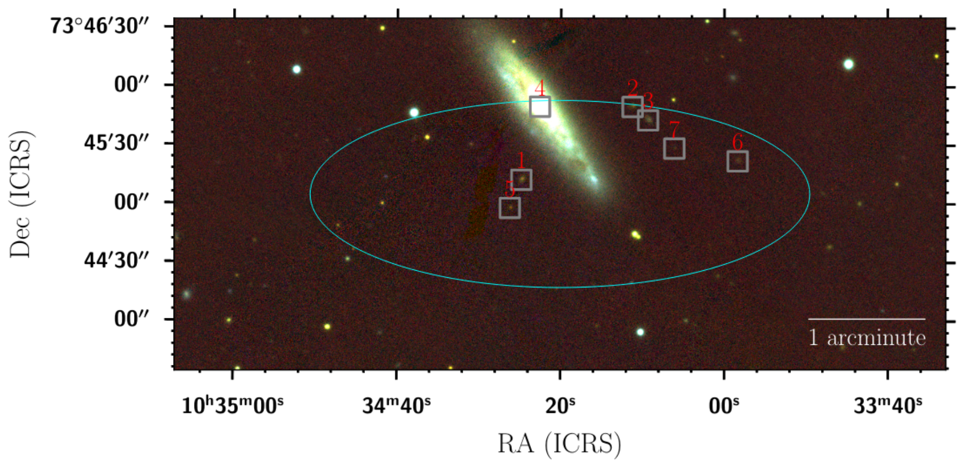

Figure 2. Pan-STARRS RGB-image of the FRB 20181030A 90% localization region (cyan ellipse). Grey boxes show the locations of 7 host galaxy candidates within the localization region (See Table 4); Source 4 is NGC 3252 at z = 0.0039, the most promising host galaxy of the FRB.

- 根据测谱得到的红移, 只有NGC3252满足红移限制.

Table 4. Galaxies identified within the FRB localization region with $M_r < -15$ AB mag at $z_{max} = 0.05$.

Number	R.A. J2000	Dec. J2000	DESI(r-band)[a] AB mag.	Identified lines	z_{spec}
1	$10^h34^m24.^s81$	$73^\circ45'12.''81$	19.69	[OII], Ca doublet, G-band	0.460(1)
2	$10^h34^m11.^s23$	$73^\circ45'49.''23$	19.89	Ca doublet, G-band, Mg, Na	0.455(2)
3	$10^h34^m9.^s33$	$73^\circ45'42.''33$	19.41	[OII], Ca doublet, [OIII] doublet	0.276(2)
4[b]	$\mathbf{10^h34^m22.^s56}$	$\mathbf{73^\circ45'49.''56}$	**12.58**	see text	**0.00385(2)**
5	$10^h34^m26.^s20$	$73^\circ44'57.''20$	21.61	Ca doublet, G-band, Mg, Na	0.645(1)
6	$10^h33^m58.^s36$	$73^\circ45'21.''36$	20.76	Ca doublet, G-band	0.647(1)
7	$10^h34^m6.^s12$	$73^\circ45'28.''12$	21.67	[OII], Ca doublet	0.563(2)

- 现在才发这个源宿主星系的文章是因为之前数据不够而达不到精度?
  - 2019年CHIME/FRB Collaboration报告了这个源之后, 又探测了该源的7次重复爆发. 根据其中几次的raw voltage data, 可以将定位范围限制在几个角秒. 在这个基础上作者找到了NGC 3252.

Table 1. Properties of the bursts from FRB 20181030A.

TNS Name	MJD	Arrival Time[a] (UTC @ 400 MHz)	S/N[b]	DM^c_{bb} (pc cm^{-3})	DM[d] (pc cm^{-3})
FRB 20181030A[e]	58421	04:13:13.1758(8)	32.5	–	103.5 ± 0.7
FRB 20181030B[e]	58421	04:16:21.6419(14)	17.1	–	103.5 ± 0.3
FRB 20200122A	58870	10:20:32.5805(3)	13.9	103.53 ± 0.02	103.40 ± 0.14
FRB 20200122B	58870	10:27:00.4412(3)	17.3	103.49 ± 0.02	103.47 ± 0.08
FRB 20200122C	58870	10:28:20(1)	8.3	–	103.1 ± 1.2
FRB 20200122D	58870	22:09:30.8575(3)	13.1	103.58 ± 0.19	103.7 ± 0.4
FRB 20200122E	58870	22:09:52(1)	10.4	–	103.27 ± 0.13
FRB 20200122F	58870	22:22:21(1)	8.9	–	103.7 ± 0.7
FRB 20200122G	58870	22:23:20.3080(3)	10.5	103.57 ± 0.10	103.7 ± 0.5

58870为2020年1月22日, 但作者应该是在2021年1月7日才知道的, 所以写的比较晚.

背景知识:

- 所有得到了定位的FRB(15个)中, 除了FRB20200120E, 其它的红移均位于0.03-0.66之间.
- 目前只在射电波段能观测FRB, 没有报道有类似余辉这种可在其它波段看见的辐射.
- CHIME/FRG网站:https://www.chime-frb.ca