The molecular gas kinematics in the host galaxy of non-repeating FRB 180924B

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Paper link

Hsu et al. accepted by MNRAS

What are FRBs?

Fast radio bursts (FRBs) are millisecond-duration radio transients. They are classified into two types: repeating and non-repeating FRBs. In fact, there are more than 800 FRBs that have been detected. However, the origin of FRBs is still a mystery in the astronomy field.

FRB imaginary image

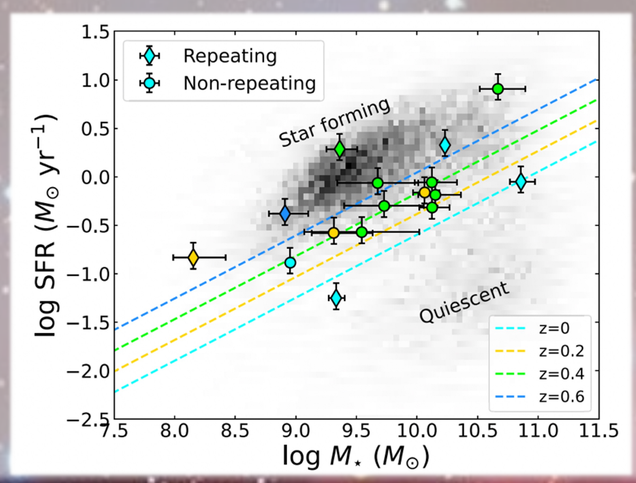
Credit: Danielle Futselaar/ASTRON, artsource.nl.

Problem: Diverse properties in host galaxy

In the previous optical observation, both repeating and non-repeating FRBs show diverse properties in their host galaxies.

➡ No conclusive answer

Bhandari at el. 2022



Solution: Molecular gas kinematics

Mapping the molecular gas kinematics in the host galaxy of non-repeating FRB 180924B with ALMA telescope which is in submillimeter wavelength.

Why is molecular gas important?

Molecular gas is the fuel of star formation. Understanding its kinematics allows us to investigate variable physical processes of host galaxies (e.g., merger or smooth rotation), which may be the link to the birth of FRB.

ALMA

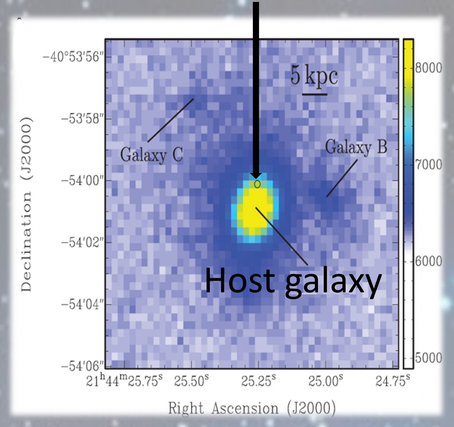
Credit: ALMA

Result: First molecular gas kinematics in FRB host

Host galaxy

Massive spiral galaxy
- redshift: z = 0.3216

Non-repeating FRB 180924B



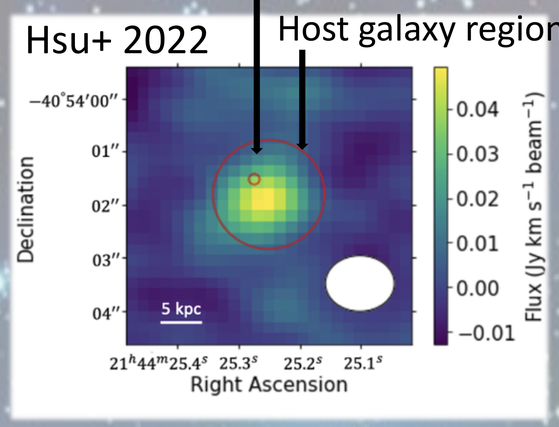
Bannister et al. 2019

First CO detection

Velocity integrated intensity map
Integration range: -180 ~ 110 km/s

FRB 180924B

Hsu+ 2022

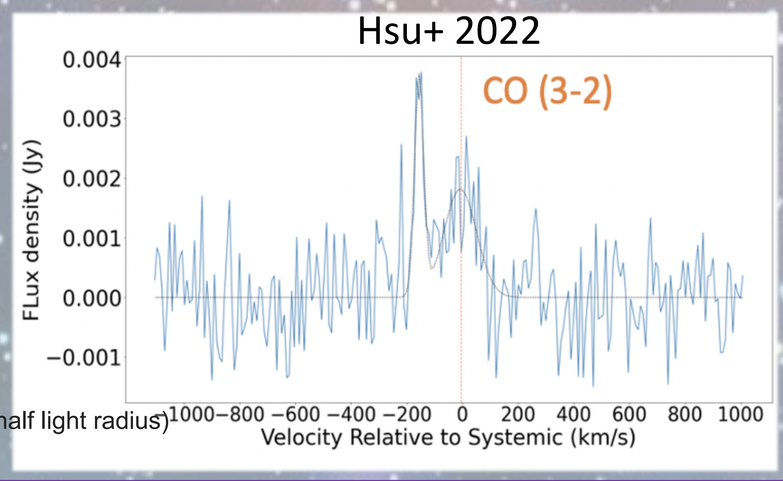


- Large red circle: Host galaxy region (its position with 2*half light radius)
- Small red circle: FRB region (its position with error)

Asymmetric CO spectrum

CO spectrum:
- Blue line: Observed data
- Black line: Best-fit Gaussian function

Hsu+ 2022

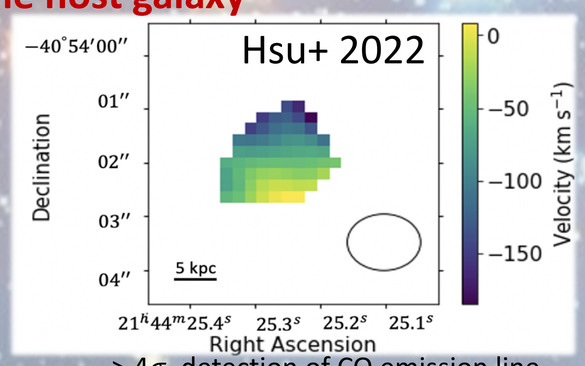


Velocity gradient

Velocity field of host galaxy region:
- Smooth velocity gradient
- Range from 180~8 km/s
- Missing symmetric velocity component

-> Disturbed molecular gas kinematics in the host galaxy

Hsu+ 2022



> 4σ detection of CO emission line

High A_{peak} value

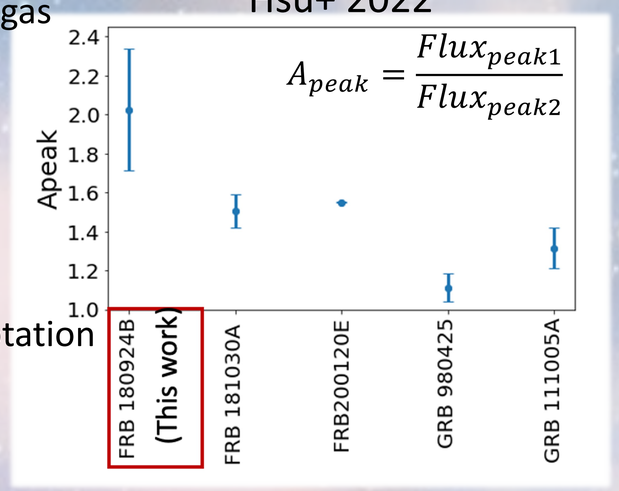
Comparison to A_{peak} value of asymmetric HI spectrum of FRB hosts and not asymmetric HI spectrum of GRB hosts :
- A_{peak} :The peak ratio of the two velocity components in the CO spectrum
- FRB 180924B host spectrum is highly asymmetric with $A_{peak} = 2.0 \pm 0.4$

-> Disturbed molecular gas kinematics are found in the host of FRB 180924B

Disturbed gas

Smooth rotation

Hsu+ 2022



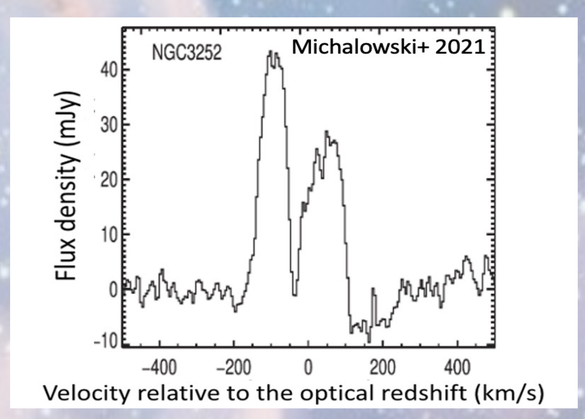
Note: HI spectrum of FRB 181030A and FRB 200120E are regarded as asymmetric and not asymmetric in GRB 980424 and GRB 111005A by Michalowski+ 2021

Discussion

Comparison to HI detection of FRB host galaxy

3 Repeating FRB hosts show disturbed HI gas
- Kaur+2022 shows a merging HI gas system in the host galaxy of FRB 180916B
- Michalowski+2021 shows the disturbed kinetic structures of HI gas are in the the host galaxy of FRB 181030A and FRB200120E with A_{peak} = 1.5 and 1.55, respectively

Asymmetric HI spectrum of FRB 181030A host



Michalowski et al. 2021

Conclusion

First molecular gas kinematics in the FRB host:
- Disturbed molecular gas kinematics are found in the host galaxy of non-repeating FRB 180924B
- Both non-repeating and repeating FRB hosts show disturbed gas structures, suggesting a possible link between the FRB progenitor and gas kinematics

Future work:
- HI observation to FRB180924B host and other FRB host galaxies with VLA
- Molecular gas observation of other FRB host galaxies with ALMA

See also:

Companion published paper

Press release