Proposed Observation, Experimental Design and Analysis Plan

We, Cheng-Lin Liao, Tzu-Shuan Kuo, and Mei-Ni Chen, propose extended array configuration SMA observations towards NGC253 and M82. They are the starburst galaxies in local Universe, which are helpful for understanding the small structures of gas in galaxies. The detailed observational setup and analyses plan are explained in the following:

Target sources and ancillary data. NGC253 and M82 are the galaxies with angular size of $27' \times 6'$ and $11' \times 4'$, and they are about 3.5 Mpc away from us. We select these two galaxies as our targets because they are very bright and close to us; therefore, they can be spatial resolved by SMA observation. A 7.5 hours observation of NGC253 was carried out by SMA compact configuration, and the ^{12}CO(2-1) channel maps are demonstrated in Sakamoto et al. (2006), as shown in Figure 1. They significantly detected ^{12}CO(2-1), ^{13}CO(2-1),^{18}CO(2-1), and 1.3 mm continuum. The ^{12}CO(2-1) and ^{12}CO(3-2) of M82 were observed by SMA with resolution at about 3" in Chisholm & Matsushita (2016). They have detailed discussions about the physics in different regions (the disk, the starburst-driven bubble, and the base of a molecular streamer) of M82.

Spectral setup. We will use the setup that $\mathrm{LO}_{R\times A}$ =230 GHz and $\mathrm{LO}_{R\times B}$ =230 GHz. This observation will cover multiple CO emission lines, such as ^{12}CO(2-1) [230.53 GHz], ^{13}CO(2-1) [220.40 GHz], and ^{18}CO(2-1) [219.56 GHz], which are good tracers of molecular hydrogen.

Angular resolution The expected angular scales are about 50" $\times$ 40" for the central region ($R \lesssim$ 0.4 kpc) of NGC253 and 10" $\times$ 20" for the central region ($R \lesssim$ 0.3 kpc) of M82. The angular resolutions is about 1.3" at 230 GHz, while the maximum recoverable angular scale is about 8".

Observing time. Based on previous ^{12}CO(2-1) observation by SMA compact configuration, the expected ^{12}CO(2-1) peak intensity in the central region of NGC253 observed by SMA extended configuration is about 1.2 Jy/beam (or 16.8 K), as discussed in Figure 1. To achieve a 10 σ measurement of the ^{12}CO(2-1) peak at 1 km/s resolution, it will take about 2 hours to observe the target and obtain the noise intensity level at about 0.12 Jy/beam (or 1.72 K). Therefore, we request to observe NGC253 staring from HA= -1.5 to HA= 1.5, including the on-source time and the instrument calibration time. The prediction about the observation from SMA Beam Calculator / Sensitivity Estimator is in Figure 3.

The zeroth-moment map, which is the integrated intensity map, of ^{12}CO(2-1) in the central region of M82 is presented in Chisholm & Matsushita (2016), as shown in Figure 2, where the peak ^{12}CO(2-1) integrated intensity is about 2250 K km/s. We divide the peak integrated intensity by the bandwidth they integrated, 330 km/s, and obtain the average intensity as 6.8 K, which served as the lower limit of the expected peak intensity. To achieve at least a 4.5 σ measurement of the ^{12}CO(2-1) peak at 1 km/s resolution, it will need about 3-hour on-source time to obtain the noise intensity level at about 1.54 K. Therefore, we request to observe M82 staring from HA= -5.5 to HA= -1.5, including the on-source time and the instrument calibration time. The prediction about the observation from SMA Beam Calculator / Sensitivity Estimator is in Figure 4.

We summarize some information related to the observation of our targets in Table below, where frequency dependent quantities are estimated at 230 GHz and the sensitivity is at 1 km/s. Figure 5 demonstrates the altitude of the targets and the moon during the night on 11, Nov, 2022 at Mauna Kea Observatory.

Targets	RA & Dec	Intensity	Sensitivity	S/N	HA	Beam	Max Scale
NGC253	$00^h47^m33.2^s$ $-25°17'17.1"$	16.8 K	1.72 K	10	$-1.5 \sim +1.5$	1.44"×1.19"	10.24"×8.46"
M82	$09^h55^m51.9^s$ $+69°40'47.1"$	6.8 K	1.54 K	4.5	$-5.5 \sim -1.5$	1.79"×1.18"	10.12"×6.67"

Reference

[1] Sakamoto et al. 2006, 636, 685 [2] Chisholm & Matsushita 2016, 830, 72

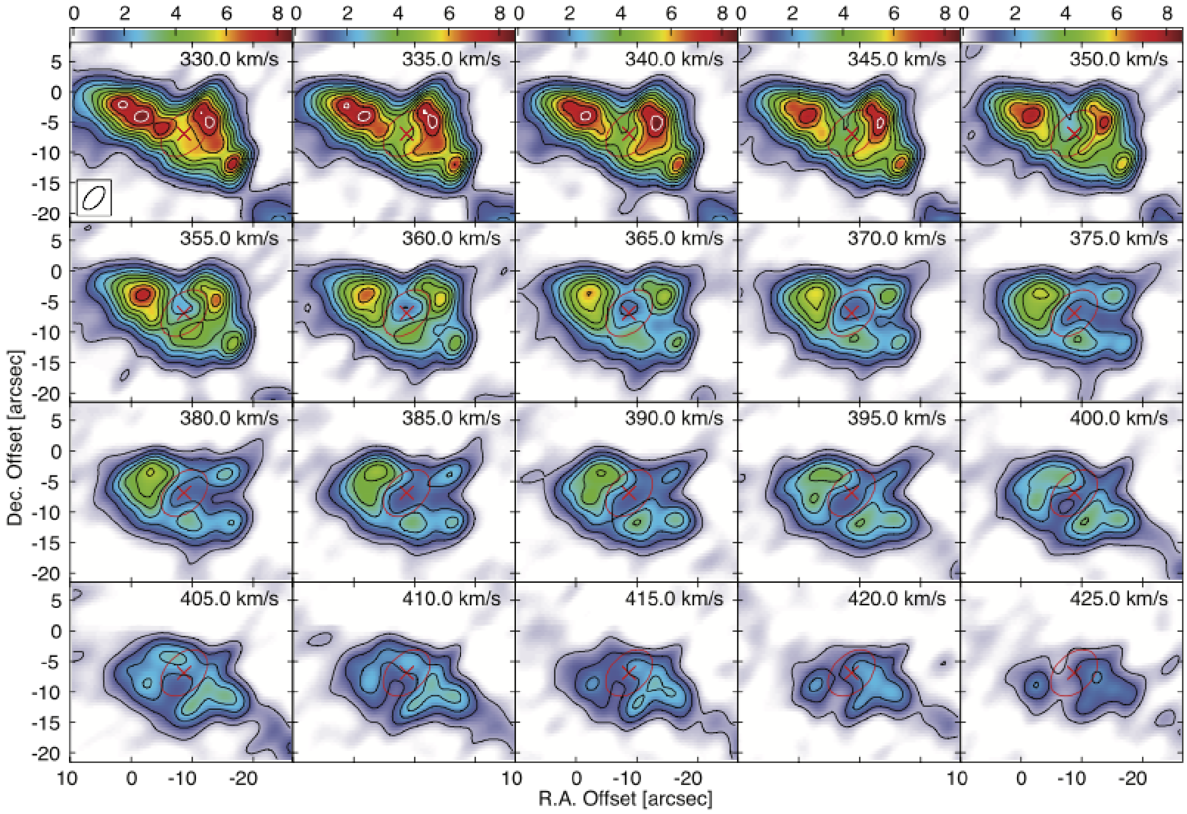


Figure 1: ^{12}CO(2-1) channel maps of NGC253 presented in Sakamoto et al. (2006). The conversion between Jy/beam and excess brightness temperature is 1 Jy/beam=2.1 K. The peak intensity is about 8 Jy/beam in their observation, which is about 1.2 Jy/beam in this proposed observation because their beam size (4.6" × 2.4") is about 6.4 times larger than ours (1.44" × 1.19").

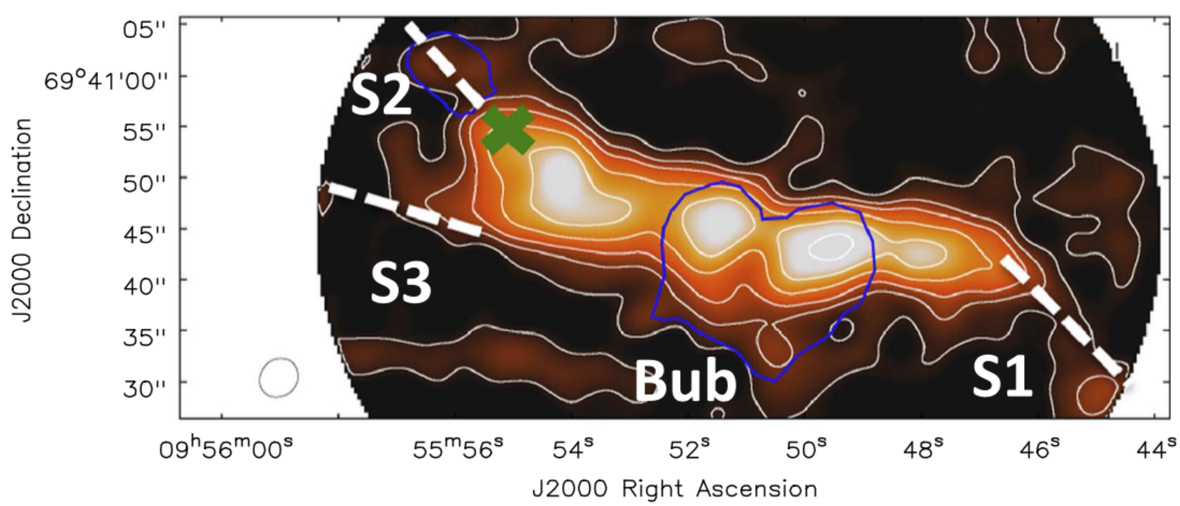
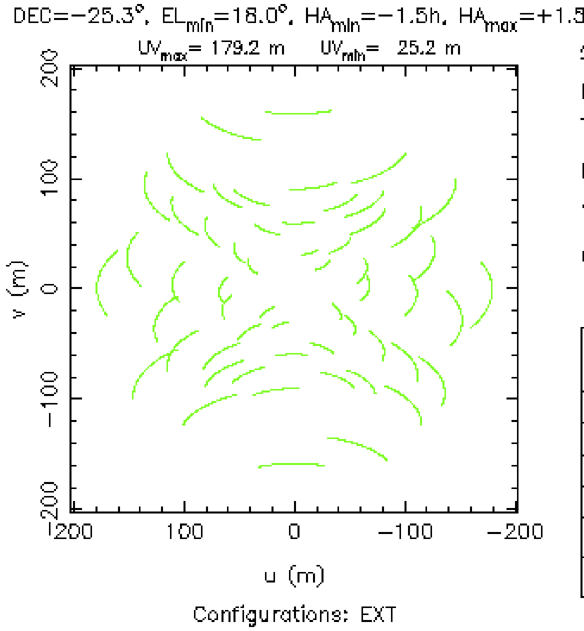


Figure 2: Zeroth-moment map of M82 presented in Chisholm & Matsushita (2016). The contour levels are 450, 600, 750, 1050, 1500, and 2250 K km/s, and the velocity integration range is from −180 to +150 km/s.



NOISE ESTIMATE –– Natural Weights

Assumes requested frequency placed at 10 GHz in IF

LO Freq=220.0 GHz η_{AP}=0.776

T_{RX}(DSB)= 66.2 K η_{MISC}=0.920

PWV: 4.00 mm $\tau_{225\ GHz}$=0.210

τ_{lsb}= 0.196 τ_{usb}= 0.214

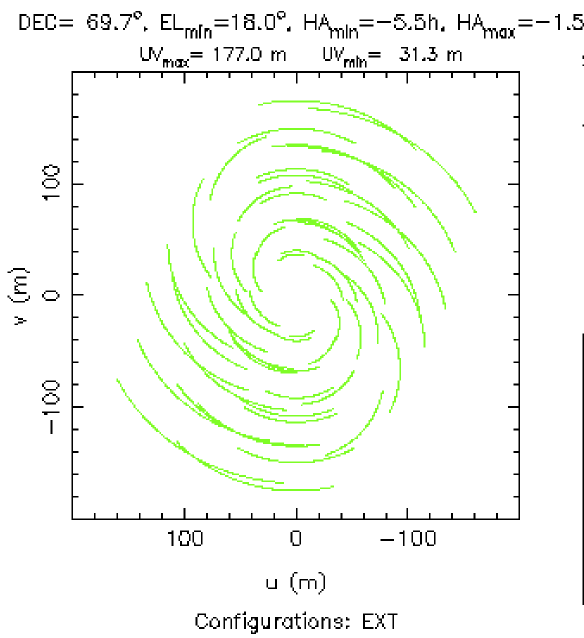
On−source = 2.02 hr Beam$_{LO}$= 1.44"× 1.19"

	RMS NOISE/BEAM			
BANDWIDTH	LSB (210.0 GHz) FLUX	LSB (210.0 GHz) T(RJ)	USB (230.0 GHz) FLUX	USB (230.0 GHz) T(RJ)
12 GHz[1]	0.95 mJy	14.1 mK	0.98 mJy	14.5 mK
2 GHz	2.22 mJy	32.8 mK	2.28 mJy	33.7 mK
100 km/s	11.8 mJy	175.3 mK	11.6 mJy	172.0 mK
1 km/s	118.4 mJy	1.75 K	116.2 mJy	1.72 K
SINGLE RX USB+LSB SENSITIVITY 0.68 mJy/beam				
DUAL RX OPERATION[2]: divide above sensitivities by √2				

[1]Assumes 20% noise penalty in upper 4 GHz of IF

[2]Assumes same LO and spectral response for both Rx

Figure 3: Expected beam estimation and noise level of NGC253 from SMA Beam Calculator / Sensitivity Estimator.



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On−source = 2.68 hr Beam$_{LO}$= 1.79"× 1.18"

	RMS NOISE/BEAM			
BANDWIDTH	LSB (210.0 GHz) FLUX	LSB (210.0 GHz) T(RJ)	USB (230.0 GHz) FLUX	USB (230.0 GHz) T(RJ)
12 GHz[1]	1.04 mJy	12.5 mK	1.08 mJy	12.9 mK
2 GHz	2.43 mJy	29.0 mK	2.51 mJy	30.1 mK
100 km/s	13.0 mJy	155.2 mK	12.8 mJy	153.6 mK
1 km/s	129.6 mJy	1.55 K	128.3 mJy	1.54 K
SINGLE RX USB+LSB SENSITIVITY 0.75 mJy/beam				
DUAL RX OPERATION[2]: divide above sensitivities by √2				

[1]Assumes 20% noise penalty in upper 4 GHz of IF

[2]Assumes same LO and spectral response for both Rx

Figure 4: Expected beam estimation and noise level of M82 from SMA Beam Calculator / Sensitivity Estimator.

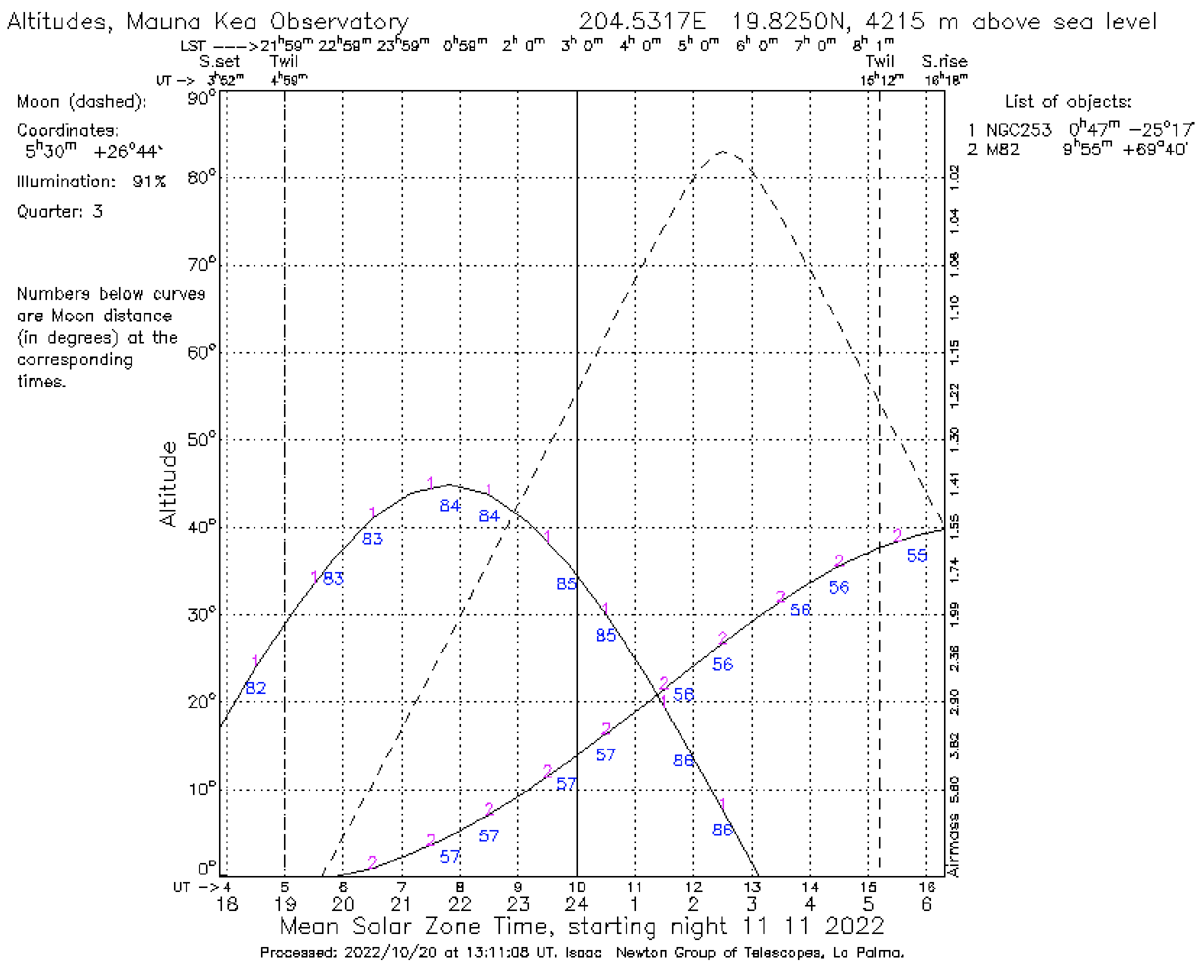

Figure 5: Altitude as function of time on 11, Nov, 2022 at Mauna Kea Observatory for NGC253, M82, and the moon derived from STARALT. The solid curves represent our targets, and the dash curve is the moon. Blue numbers below solid curves are the distance (in degree) to the moon at the corresponding time.