SSG workshop

Gemini/GNIRS spectroscopy of SNRs

2019. 2. 22

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@SSG workshop/HighOne

Gemini instruments

Gemini North Instruments

VISIBLE NEAR-IR MID-IR OTHER FACILITIES **Facility Instruments** GMOS (multi-object, longslit and IFU spectrograph NIRI (1-5µm imager) GCAL (facility calibration and imager) Instrument Fact Sheet unit) Instrument Fact Sheet ALTAIR (facility natural/laser guide star AO NIFS (1.0-2.5µm integral field spectrograph) Instrument Fact Sheet system) GNIRS (1-5µm long-slit and 0.9-2.5µm cross-dispersed spectrograph; formerly at Gemini South) Instrument Fact Sheet **Visiting Instruments** GRACES (0.4-1.0µm high resolution spectrograph) 'Alopeke (diffractionlimited optical imager) POLISH2 (optical polarimeter)

Expected to be available in 2019A. For more info on these or other Visiting Instruments, contact geminivip@gemini.edu

Gemini South Instruments

VISIBLE	NEAR-IR	MID-IR	OTHER FACILITIES
	Facility Instru	ments	
GMOS (multi-object, long- slit and IFU spectrograph and imager) Instrument Fact Sheet			GCAL (facility calibration unit)
	GSAOI (high-resolution imager for use with Multi- Conjugate Adaptive Optics system "GeMS") Instrument Fact Sheet		GeMS (Multi-conjugate adaptive optics system)
	GPI (adaptive-optics imaging polarimeter/integral-field spectrometer) Instrument Fact Sheet		
	FLAMINGOS-2 (long-slit spectrograph and imager) Instrument Fact Sheet		
	Visiting Instru	ments	
DSSI (diffraction-limited optical imager)	Phoenix (high-resolution spectrograph)		

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Which is brighter?

• Same source with different aperture



Which is brighter?

Same line with different bandwidth





Emission line source

- Continuum : one can get more flux when increasing basket.
- Line : same flux

 Line signal gets relatively weaker as bandwidth increases and vice versa

Spectroscopy

Finding line-emitting source in narrow band image

Kepler's SNR



[Fe II]-band

UWIFE survey

Lee, J.-J. et al. 2014, MNRAS, 443, 2650 [Fe II] imaging survey of the Milky Way (gems0.kasi.re.kr/uwife)



E Slope</=2.5% Cuton 0.529



[Fe II] mini-survey of nearby galaxies

Secondary product of UWIFE project

Natural track : MW -> nearby galaxies

Usage of time blocks when the MW has no/little visibility

Not always in best condition



Target galaxies

M33

M74

NGC247

6/20/2012

6/20/2012

6/25/2012

6/21/2012

6/21/2012

7/6/2012

[Fe II] & H imaging : mostly 4 x 15 min. exposure

Name	RA			DE	C		Size		Dista	ance Typ
M83	13	37	00.4	-29	52	04	12.2	9.39	4.47	SBC
M101	14	03	12.6	+54	20	55	28.8	26.9	6.7	Sc
M51pair	13	29	53.4	+47	12	48	8.22	5.59	8	Sc
NGC4214	12	15	39.6	+36	19	39	4.81	3.08	2.92	I
M33	01	33	51.0	+30	37	37	29.4	23.5	0.84	Sc
M74	01	36	41.8	+15	47	00	6.78	5.83	7.3	Sc
NGC247	00	47	08.8	-20	45	38	9.75	5.36	3.65	SsD
		1		2		3	4		5	н
M82										
M83	7/6/	2012	2	7/7/2012	1	7/7/2012	7/8/2012			7/9/2012
M101	6/24	/201	2	7/9/2012	7/10/2012		7/11/2012	7/12	/2012	6/26/2012
M51	6/25	/201	2	7/6/2012	7/7/2012		7/8/2012			6/23/2012
NGC4214	7/13	/201	2							7/13/2012

6/22/2012

6/22/2012

7/6/2012

6/26/2012

7/6/2012

7/7/2012

7/7/2012

7/7/2012

6/22/2012

6/20/2012

7/6/2012

Observed region of M33

Central 13' region



DSS 1° image & UKIRT 13' FoV

Extragalactic

• M33



x10 bandwidth, x1/10 exposure







Star-subtracted [Fe II] ([Fe II]-H), [Fe II]-H:H:Hα (R:G:B), Hα, [S II], Spitzer 8 μm, and Herschel 160 μm images of SNR G98-28 and giant H II region NGC 595 in M33.

Detected [Fe II] SNRs

Positions of 6 [Fe II] SNRs

(01:33:29.0, +30:42:17), (01:33:31.2, +30:33:33) (01:33:35.9, +30:36:28), (01:33:54.7, +30:45:19) (01:33:54.8, +30:33:10), (01:34:10.7, +30:42:24)

Basic data from Table 3 of Long et al. 2010

							18	13					63
Name	Other*	R.A. (J2000)	Decl. (J2000)	Dia. (pc)	Morph.	Env.	Radio**	Sur. Bright [†] Ha	$L_{\rm H\alpha}$ (erg s ⁻¹)	[N 11]:Ηα	[S 11]:Hα	[SII]-rat.	Spec. Ref.
L10-036	G98-28	01:33:29.05	+30:42:17.0	18	A	1	С	5.0e-15	6.5e+36	0.59	1.13	1.11	S93
L10-039	G98-31	01:33:31.25	+30:33:33.4	13	A	1	с	1.5e-14	9.6e+36	0.86	0.95	0.78	MMT-BCS
L10-045	G98-35	01:33:35.90	+30:36:27.4	30	Α'	2	с	5.8e-15	2.0e+37	0.57	0.82	1.10	MMT-BCS
L10-070	G98-54	01:33:54.51	+30:45:18.7	21	B	3	с	2.2e-15	3.7e+36	0.47	0.83	1.41	G98
L10-071	G98-55	01:33:54.91	+30:33:11.0	20	Α	2	С	5.0e-15	8.1e+36	0.48	0.83	1.12	S93
L10-096	G98-73	01:34:10.70	+30:42:24.0	18	Α	1	с	3.7e-15	5.0e+36	0.59	1.25	1.15	S93

A: well defined (A': small, bright), B: partial shell, C: poorly defined 1: isolated, 2: within nebulosity but separable, 3: confused

How bright?

[Fe II]-bright Galactic SNRs (G11.2-0.3, RCW103) & N49 in LMC



Comparison with prev. obs.

Scattered ...

Difference in emitting mechanism?



H2 image

Integration time (1/4 of [Fe II] image)





-1.21e-05 -2.99e-06 5.98e-06 1.50e-05 2.408-05 3.30e-05

5.10e-05

Gemini/GNIRS spectroscopy

- JHK band
- R ~ 1700
- Band 3 (again)
- Blind offset

Observing reference

• Nearby H=16 mag star



Slit and ref. star positions on [Fe II] image. Invisible on H image.

Tried in (Infrared) bright sky

- Just after twilight : first fits file at UT 04:44 •
- 150 s x 4

📲 🎦 📲 📕 📲 📲 📲 🖉 Base Sequence Component

This component contains the sequence of operations that generates the observation science data

File Edit Font

Data Label	Class	P	Q	Exposure Time	Read Mode	Guide With PWFS2	Cal Coadds	Cal Diffuser	Cal Exposure Time	Cal Filter	Cal Lamp
GN-20168-Q-84-44-001	Science	0.0	1.0	150.0	Very Faint Objects	guide					
SN-20168-0-84-44-002	Science	0.0	2.0	150.0	Very Faint Objects	guide					
5N-20168-Q-84-44-003	Science	0.0	2.0	150.0	Very Faint Objects	guide					
SN-20168-Q-84-44-004	Science	0.0	-1.0	150.0	Very Faint Objects	quide					
5N-20168-Q-84-44-005	Nighttime Partner Calibration	0.0	0.0	0.6	Bright Objects	freeze	1	88	0.6	none	Ar arc
N-20168-0-84-44-006	Nighttime Partner Calibration	0.0	0.0	0.6	Bright Objects	freeze	1	18	0.6	00012	Ar arc
0N-20168-0-84-44-007	Nighttime Partner Calibration	0.0	0.0	12.0	Bright Objects	freeze	1	IA.	12.0	NR balance	IR grey body - N
SN-20168-Q-84-44-008	Nighttime Partner Calibration	0.0	0.0	12.0	Bright Objects	freeze	1	將	12.0	NR balance	IR grey body - h
3N-20168-Q-84-44-009	Nighttime Partner Calibration	0.0	0.0	12.0	Bright Objects	freeze	1	8	12.0	NR balance	IR grey body - h
SN 20168 Q 84 44 010	Nighttime Partner Calibration	0.0	0.0	12.0	Bright Objects	freeze	1	18	12.0	MR balance	IR grey body - hi
SN-20168-Q-84-44-011	Nighttime Partner Calibration	0.0	0.0	12.0	Bright Objects	freeze	1	(A.	12.0	NIR balance	IR grey body - hi
SN 20168 0 84 44 012	Nighttime Partner Calibration	0.0	0.0	12.0	Bright Objects	freeze	1	IR.	12.0	NR balance	IR grey body hi
SN-20168-0-84-44-013	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	fréeze	1	iR.	1.8	ND2:0	Quartz Halogen
5N-20168-Q-84-44-014	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	freeze	1	IR	1.8	ND2.0	Quartz Halogen
5N-20168-Q-84-44-015	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	freeze	1	IR.	1.8	N02.0	Quartz Halogen
SN-20168-Q-84-44-016	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	freeze.	1	iR	1.8	ND2.0	Quartz Ralogen
SN-20168-Q-84-44-017	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	freeze	1	IA	1.0	ND2.0	Quartz Halogen
5N-20168-Q-84-44-018	Nighttime Partner Calibration	0.0	0.0	1.0	Bright Objects	freeze	1	IA.	1.0	ND2.0	Quartz Halogen
N-20168-Q-84-44-019	Nighttime Partner Calibration	0.0	0.0	1,8	Bright Objects	freeze	1	18	1.8	N02.0	Quartz Halogen
SN-20168-0-84-44-020	Nighttime Partner Calibration	0.0	0.0	18	Bright Objects	freeze	1	IR.	1.8	ND2.0	Quartz Halogen
SN-20168 Q 84 44 021	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	freeze:	1	18	1.8	ND2.0	Quartz Halogen
GN-20168-0-84-44-022	Nighttime Partner Calibration	0.0	0.0	1.8	Bright Objects	freeze	1	18	1.8	ND2.0	Guadz Halagen

Target: M33_51 - B Observing Log 9 A GNRS Sequence (45) Acq: "After" standard A0 [46] Obs: "After" standard A0 spectrum [47] Daytime pinhole observations [154] Obs: "Before" standard A1 spectrum R M33_S6 - [1] GNIRS Spectroscopy 0.15'/pix 32 l/mm grating SXD 0.30 arcsec war M33 53 - 111 GNIRS Spectroscopy 0.15*/pix 32 l/mm grating SXD 0.30 arcsec wat 👼 M33_S4 - [1] GNIRS Spectroscopy 0.15"/pix 32 Umm grating SXD 0.30 arcsec wa

M33 S2 - [1] GNIRS Spectroscopy 0.15'/pix 32 l/mm grating SXD 0.30 arcse 🗮 M33_S1 - [1] GNIRS Spectroscopy 0.15 /pix 32 l/mm grating SXD 0.30 arcse High priority target - finding chart attached BUND OFFSET ACQUISITION 1122] Acq: "Before" standard Al [123] Obs: "Before" standard A1 spectrum [42] Acq. Blind offset target (H > 20)

R NIR spectroscopy of strong line emitting SNRs in M33

PARALLACTIC ASICI E Phase # filling - Overfilled Finding chart

> SNIRS Description Description Description Target: M33_S1 Observing Log Sequence [44] Obs: Science target GNIRS Observing Conditions

- M33 55 [1] GNIRS Spectroscopy 0.15"/pix 32 l/mm grating SXD 0.30 arcsec war
- KM M33_56 Long-silt (Fell) observation 0.05*/pix 111 l/mm grating 0.10 arcsec wavel
 M33_51 Long-silt (Fell) observation 0.05*/pix 111 l/mm grating 0.10 arcsec wavel



💌 Mauna Kea 🔿 Cerro Pacler Altitude 🗋 Parallactic Angle 🗋 Elv. Constraints 💭 Timing Wind. 💌 UT 🔿 Sidereal Time 🖓 Site *

Raw spectra

Source & telluric



Reduced spectra



Extracted spectra



Ejecta? Swept-up?

- Radial velocity
 - R~1700, ∆Vr~200 km/s
 - Less likely ejecta
- Luminosity
 - A few hundreds Lsun

Not a simple environment

- Atomic line ([Fe II])
 - Shocked compressed gas
 - Gas density ~ 10² 10⁵ cm⁻³
 - Preshock density n > 10 cm⁻³
- Molecular line (H2)
 - Molecule formation behind shock front or Interaction with molecular cloud
 - Preshock density > 10³ cm⁻³

Radiative shock model

- Mappings III
 - n = 1 cm-3, solar abundance



Lesson today

- SNR in M33 is detectable
 - Only exposure of 150 s x 4
 - Bright sky
- Emission line source needs blind offset
 - Even though short exposure target
- If extended, positional tolerance can be large
 - Blind offset but no precise accuracy
- Bright, extended targets in MW
 - Candidate for band 4