SNe and SNRs in nearby galaxies

: near-infrared [Fe II] observations

Ho-Gyu Lee 2013 April 18

[Fe II] filter

Southeastern shell of G11.2-0.3

- JH (1.0-1.8um)
- [Fe II] lines + faint He I
- Our near-infrared [Fe II] filter
 - Peak: around 1.644um line
 - Minimize contributions from other transitions
 - Shifted toward blue side



E Slope</=2.5% Cuton 0.529



UKIRT [Fe II] project

- Main project: UWIFE
 - UKIRT Wide-field Infrared Survey for Fe+



- Additional observations
 - Bright SNRs
 - Nearby galaxies



Visibility of the galactic plane at Hawaii

SNe & SNRs in nearby galaxies

Observed galaxies

Name	RA	DEC	C	Size		Dista	ance Type
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	5	Н
M82	1	2	3	4		5	Н
M82 M83	1 7/6/2012	2 7/7/2012	3 7/7/2012	4 7/8/2012		5	H 7/9/2012
M82 M83 M101	1 7/6/2012 6/24/2012	2 7/7/2012 7/9/2012	3 7/7/2012 7/10/2012	4 7/8/2012 7/11/2012	7/12/	2012	H 7/9/2012 6/26/2012
M82 M83 M101 M51	1 7/6/2012 6/24/2012 6/25/2012	2 7/7/2012 7/9/2012 7/6/2012	3 7/7/2012 7/10/2012 7/7/2012	4 7/8/2012 7/11/2012 7/8/2012	7/12/	2012	H 7/9/2012 6/26/2012 6/23/2012
M82 M83 M101 M51 NGC4214	1 7/6/2012 6/24/2012 6/25/2012 7/13/2012	2 7/7/2012 7/9/2012 7/6/2012	3 7/7/2012 7/10/2012 7/7/2012	4 7/8/2012 7/11/2012 7/8/2012	7/12/	2012	H 7/9/2012 6/26/2012 6/23/2012 7/13/2012
M82 M83 M101 M51 NGC4214	1 7/6/2012 6/24/2012 6/25/2012 7/13/2012	2 7/7/2012 7/9/2012 7/6/2012	3 7/7/2012 7/10/2012 7/7/2012	4 7/8/2012 7/11/2012 7/8/2012	7/12/	2012	H 7/9/2012 6/26/2012 6/23/2012 7/13/2012
M82 M83 M101 M51 NGC4214 M33	1 7/6/2012 6/24/2012 6/25/2012 7/13/2012 6/20/2012	2 7/7/2012 7/9/2012 7/6/2012 6/21/2012	3 7/7/2012 7/10/2012 7/7/2012 6/22/2012	4 7/8/2012 7/11/2012 7/8/2012 6/26/2012	7/12/	2012	H 7/9/2012 6/26/2012 6/23/2012 7/13/2012 6/22/2012
M82 M83 M101 M51 NGC4214 M33 M74	1 7/6/2012 6/24/2012 6/25/2012 7/13/2012 6/20/2012 6/20/2012	2 7/7/2012 7/9/2012 7/6/2012 6/21/2012 6/21/2012	3 7/7/2012 7/10/2012 7/7/2012 6/22/2012 6/22/2012	4 7/8/2012 7/11/2012 7/8/2012 6/26/2012 7/6/2012	7/12/	2012	H 7/9/2012 6/26/2012 6/23/2012 7/13/2012 6/22/2012 6/20/2012

M33[Fe II] FoV on optical (DSS red 1d) image



Data processing

CASU (Cambridge Astronomical Survey Unit) provides
 (Pre)processed image and photometric catalog for each run

- Combine images (scaled using bright stars)
 - [Fe II] : 2 x 4 days
 - H: 2 fames x 1 day
- [Fe II] H
- Background subtraction
- And more ...



[Fe II] – H

[Fe II]

Н





Detected bright SNRs

Positions

(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)

SNR basic data from Table 3 of Long et al. 2010

Name	Other*	R.A. (J2000)	Decl. (J2000)	Dia. (pc)	Morph.	Env.	Radio**	Sur. Bright $_{H\alpha}^{\dagger}$	$L_{\rm H\alpha}$ (erg s ⁻¹)	[N 11]:Hα	[S 11]:Hα	[SII]-rat.	Spec. Ref.
L10-036	G98-28	01:33:29.05	+30:42:17.0	18	Α	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	A'	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	В	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	A	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

Characteristics

X-ray bright and intermediate(?) size

Chandra X-ray (Long et al. 2010)

Not covered

There are seven SNRs in M33 that stand out in terms of their X-ray brightness—G98-21 (29 pc diameter), G98-28 (22 pc), G98-29 (40 pc), G98-31 (17 pc), G98-35 (34 pc), G98-55 (24 pc), and G98-73 (22 pc). These remnants are sufficiently bright to allow extraction and fitting of their spectra, and also comparison of their X-ray, optical, and radio morphologies. Interestingly, all of these are intermediate-sized objects (\sim 15–40 pc across). In addition, most show evidence of significant interaction with surrounding material (e.g., strongly enhanced X-ray emission at localized spots on their boundaries).

+ G98-54: extended feature in [Fe II]

Long et al. 2010



Figure 5. Histogram of the SNRs and SNR candidates as a function of diameter in bins of 10 pc. The entire sample is shown in black. The portion of the sample that was detected at 2σ or higher is shown in blue, and at 3σ or higher in red. All of the objects with diameters greater than 100 pc are plotted in the last bin. The median diameter of objects which were detected in X-rays is 38 pc, compared to 55 pc for the objects which were not detected.

Giant H II region

SNR G98-28

[Fe II]-H:H:Hα (R:G:B),



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



Spitzer 3.6, 4.5, 5.8 8.0, Spitzer 24, 70, Spitzer 140um, [Fe II]

Mid-IR detection of G98-28

- Spitzer IRAC and MIPS 24um
- Possible contributors
 - (1) Continuum by small, hot dust
 - (2) Emission lines such as H2 or atomic lines
- If (2) is correct, we are looking at an SNR interacting with molecular cloud outside our Galaxy (+ L/SMC)
 - New proposal for confirm?
 - Anyway, H2 imaging is interesting

M83







SNe in M51 and M101

About 1 year after explosion

Host G.	Dist.	SN	Туре	Date (Exp.)	Date (Obs.)	[Fe II]	Н
M101	6.7 Mpc	2011fe	la	Aug. 24	2012.6.247.12	15.5 mag	16.5 mag
M51	8 Mpc	2011dh	IIP	Jun. 01	2012.6.257.8	17.0 mag	18.5 mag

M101 : SN la 2011fe



M51 : SN IIb 2011dh



la: late-time (nebula) observations

Selected works



Light curve : 2003hv (Leloudas et al. 2009) Spectra (Motohara et al. 2006)

Core-collapse : late-time

Ic : 2007gr +390days



Spectra & models (Mazzali et al. 2010)

Summary and future works

- SNe and SNRs in [Fe II] images of nearby galaxies
 - 2 (SNe) and 3 (SNRs) out of 7
- Bright SNRs in M33
 - More observations!
 - CO
 - Spectroscopy
- SNe
 - Ia and core-collapse in nearby galaxies
 - Good chance to do monitoring photometry/spectroscopy
 - Near-infrared spectroscopy in 2014(?)

Opportunities for infrared spectroscopy

- IGRINS
 - HK bands
 - R ~ 40000 (immersion grating)
 - Plan: 2.7m in late 2013
- WIFIS
 - zJ bands
 - **R** ~ 3000
 - ~ 50" x 20" IFU
 - Plan: 2.3m by early 2014

IGRINS



H & K spectra in a single exposure



Figure 2: H band echellogram. The dashed lines show the ends of each order.



Pictures taken at KASI in 2013?. Now it is at Texas

Lamp spectra (H & K)





Observation

2.7m at Mcdonald observatory

2.7 m (107") Harlan J. Smith Telescope





2.7 m (107") Harlan J. Smith Telescope

Cassegrain f/8.8 Ritchey-Chretien focus

DIAFI VIRUS-P CCD WHT Camera Imaging Grism Instrument (IGI)

Coudé f/32.5 focus Robert G. Tull Coudé Spectrographs Tull Spectrograph (TS1) Cross-Dispersed Echelle Spectrograph (TS2)

Test runs in coming March

Item		H-band	K-band	
Wavelength [µm]		1.65 (1.49 ~ 1.8)	2.16 (1.96~2.46)	
Spectral resolution (R)		40,000	40,000	
Slit width (@4m telescop	e)	0.68 arcsec	0.68 arcsec	
Beam size		25 mm	25 mm	
Main dispersion grating	Glass material	Silicon	Silicon	
(Immersion Echelle	Grating angle [deg]	71.56 (R3)	71.56 (R3)	
grating)	Line density [l/mm]	36.5	36.5	
	Orders (min-max)	98-122	72-92	
Cross dispersion	Glass material	Corning Fused Silica	Heraeus (Infrasil 301)	
grating (VPHG, first		(HPFS 7980)		
order)	Grating angle [deg]	32.43	32.43	
	Line density [l/mm]	650	400	
	Order separation	11.8 – 18.3	12.1 – 20.2	
	[arcsec] (min-max)			
Detector	Туре	H2RG (2Kx2K)	H2RG (2Kx2K)	
	Pixel size [µm]	18	18	



Figure 1. Signal to noise in one hour, per resolution element, on the 2.7m

Higher S/N using binning or longer exposure