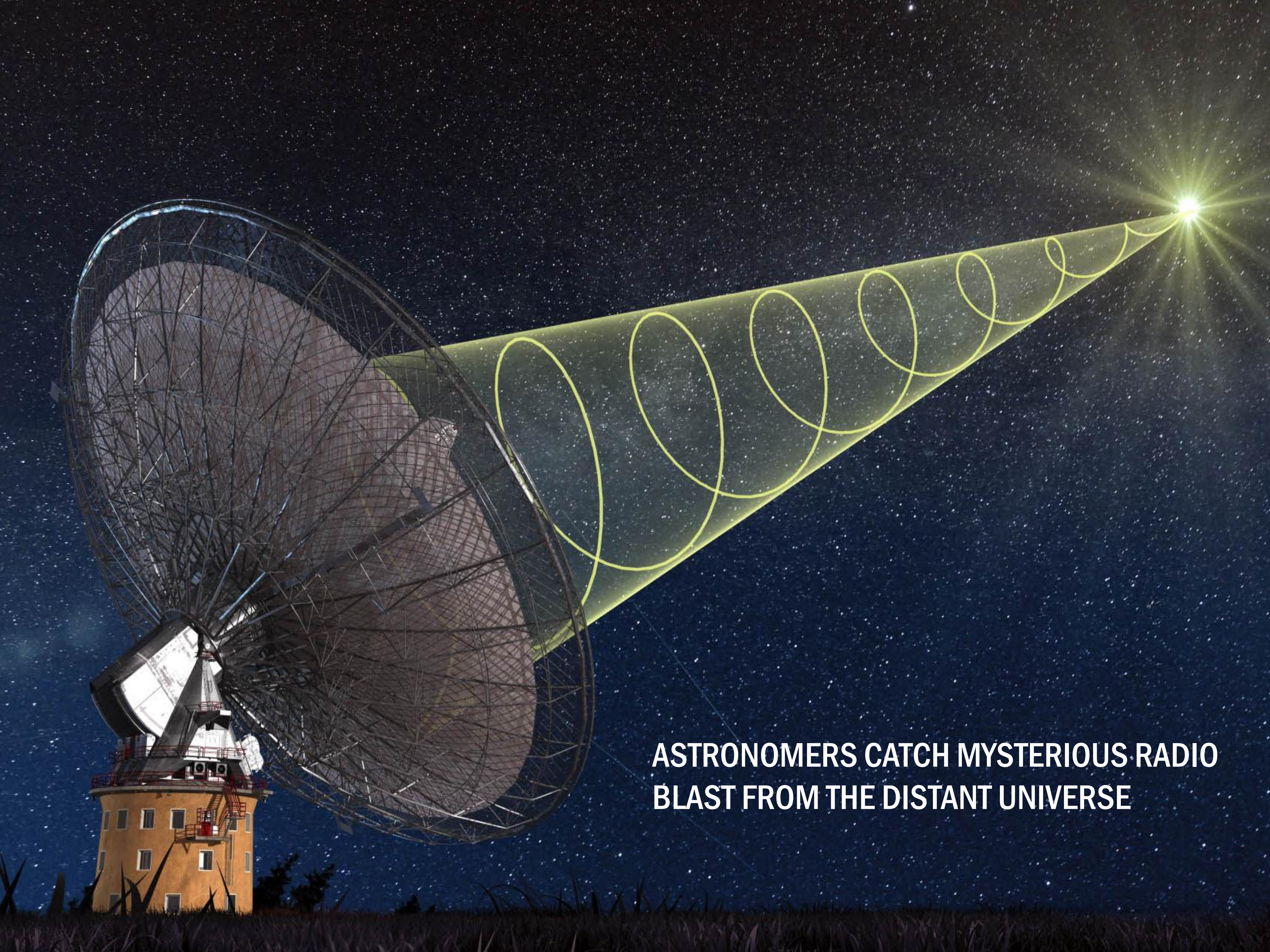
ASTRONOMERS CATCH MYSTERIOUS RADIO
BLAST FROM THE DISTANT UNIVERSE

2007

A Bright Millisecond Radio Burst of Extragalactic Origin

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Pulsar surveys offer a rare opportunity to monitor the radio sky for impulsive burst-like events with millisecond durations. We analyzed archival survey data and found a 30-jansky dispersed burst, less than 5 milliseconds in duration, located 3° from the Small Magellanic Cloud. The burst properties argue against a physical association with our Galaxy or the Small Magellanic Cloud. Current models for the free electron content in the universe imply that the burst is less than 1 gigaparsec distant. No further bursts were seen in 90 hours of additional observations, which implies that it was a singular event such as a supernova or coalescence of relativistic objects. Hundreds of similar events could occur every day and, if detected, could serve as cosmological probes.

2014

A real-time fast radio burst: polarization detection and multiwavelength follow-up

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PARKES TELECOPE

FRB 140514

Table 1. Observed properties of FRB 140514

Event date UTC	14 May, 2014
Event time UTC, $\nu_{1.4\ \mathrm{GHz}}$	17:14:11.06
Event time, ν_{∞}	17:14:09.83
Local date AEST	15 May, 2014
Local time AEST	03:14:11.06
RA	22:34:06.2
Dec	−12:18:46.5
(ℓ,b)	(50.8°, −54.6°)
Beam diameter	14.4′
$\mathrm{DM_{FRB}}$ (pc cm^{-3})	562.7(6)
$\mathrm{DM_{MW}}$ (pc cm^{-3})	34.9
Detection S/N	16(1)
Observed width, Δt (ms)	$2.8\ ^{+3.5}_{-0.7}$
Scattering timescale, $\tau_{1\mathrm{GHz}}$ (ms)	5.4(1)
Dispersion index, α	-2.000(4)
Peak flux density, $S_{\nu,1400\mathrm{MHz}}$ (Jy)	$0.47\ ^{+0.11}_{-0.08}$
Fluence, $\mathcal{F}$ (Jy ms)	$1.3\ ^{+2.3}_{-0.5}$

Table 2. Derived cosmological properties of FRB 140514

z	$< 0.44(1)$
Co-moving distance (Gpc)	$< 1.71(3)$
Luminosity distance (Gpc)	$< 2.46^{+0.04}_{-0.06}$
Energy (erg)	$< 3.7^{+4.7}_{-2.0} \times 10^{38}$
Distance modulus (mag)	< 42.2

- The source of the burst was up 5.5 billion years from Earth, near the constellation Aquarius.
- The burst could have hurled out as much energy in a few milliseconds as the Sun does in an entire day.

Parkes real time detection of FRB 140514

- The intensity profile of the fast radio burst, showing how quickly it evolved in time, last only a few milliseconds. Before and after the burst, only noise from the sky was detected.

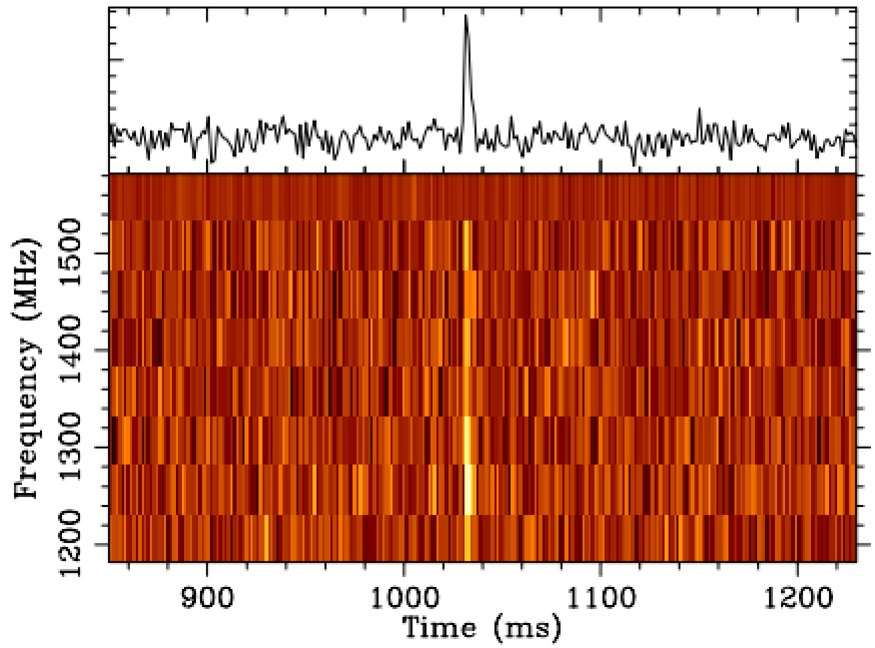


Figure 1. The pulse profile and dynamic spectrum of FRB 140514 with pulse width $2.8^{+3.5}_{-0.7}$ ms, dedispersed to DM = 562.7 pc cm^{-3} and summed to 8 frequency channels across the band. The total time plotted has been reduced to 400 ms for greater clarity. Frequency channels between 1520 to 1580 MHz are excised due to narrow-band radio interference from the Thuraya 3 satellite which transmits in this band.

FRB FOLLOW AT OTHER TELESCOPES

Table 3. Follow-up observations conducted at 12 telescopes. Limits presented are the minimum detectable magnitude or flux of each epoch. All dates are for the year 2014.

Telescope	Date Start time UTC	T+	Limits
Parkes	May 14 17:14:12	1 s	1.4 GHz - 145 mJy
ATCA	May 15 00:10:00	7 h	5.5 GHz - 40 mJy 2 GHz - 60 mJy
Parkes	May 15 23:57:38	6 h 52 m	1.4 GHz - 145 mJy
Swift	May 15 01:44:43	8 h 30 m	8.2×10^{-15} erg cm^{-2} s^{-1}
GROND	May 15 08:49:30	16 h	J - 21.1, H - 20.4, K - 18.4
Swope	May 15 09:57:13	16 h 51 m	R - 16
iPTF	May 15 11:16:03	18 h 11 m	R - 19.1
Swift	May 15 16:08:44	23 h 18 m	3.9×10^{-15} erg cm^{-2} s^{-1}
GMRT	May 16 01:30:00	1.3 d	610 MHz - 125 µJy
Effelsberg	May 16 06:50:00	1.4 d	4.8 GHz - 2.5 mJy
iPTF	May 16 11:18:21	1.7 d	R - 19.3
SkyMapper	May 16 17:57:24	2 d	Hα - 17
NOT	May 17 04:48:46	2.4 d	370 – 730 nm
GROND	May 17 09:04:13	2.6 d	J - 21.1, H - 20.5, K - 18.6
Swope	May 17 09:50:00	2.6 d	R - 16
Magellan	May 17 10:11:19	2.6 d	R - 22.5, I - 22.5
iPTF	May 17 11:15:33	2.7 d	R - 19.3
Effelsberg	May 18 03:50:00	3.4 d	2.7 GHz - 1.2 mJy
iPTF	May 19 11:23:52	4.7 d	R - 19.1
Effelsberg	May 21 05:35:00	7.5 d	1.4 GHz - 1.2 mJy
SkyMapper	May 23 17:45:48	9 d	Hα - 17
Keck	May 27 14:06:22	12.8 d	30 – 1000 nm
Swift	June 02 00:06:02	18.3 d	6.35×10^{-15} erg cm^{-2} s^{-1}
GMRT	June 03 00:20:00	19.3 d	1390 MHz - 61 µJy
NOT	June 05 03:51:09	21.4 d	370 – 730 nm
GMRT	June 08 20:30:00	24.1 d	610 MHz - 150 µJy
Parkes	June 24 14:36:40	41 d	1.4 GHz - 145 mJy
Magellan	July 8 07:34:44	55 d	R - 24.5, I - 24.5
Parkes	July 27 12:14:00	74 d	145 mJy

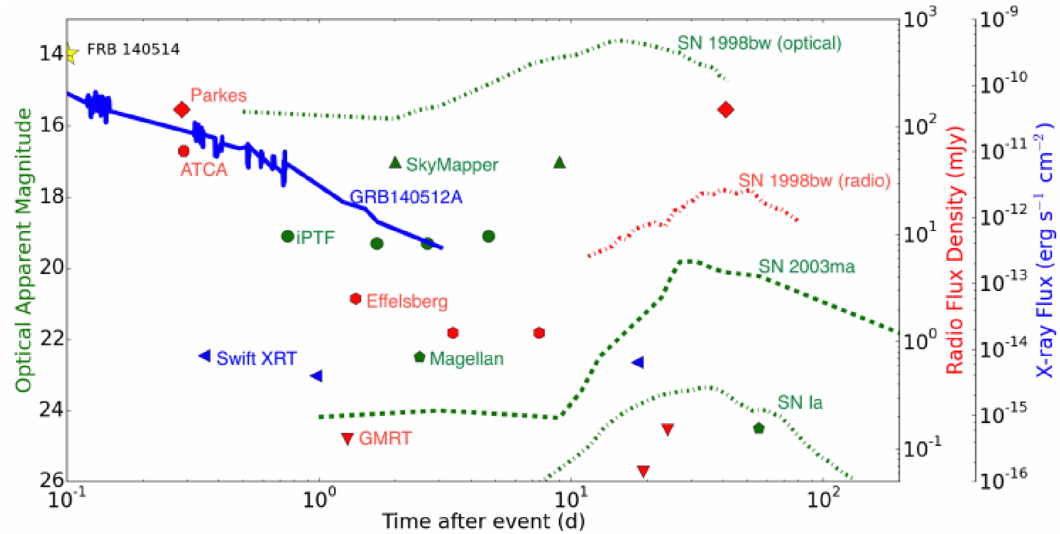
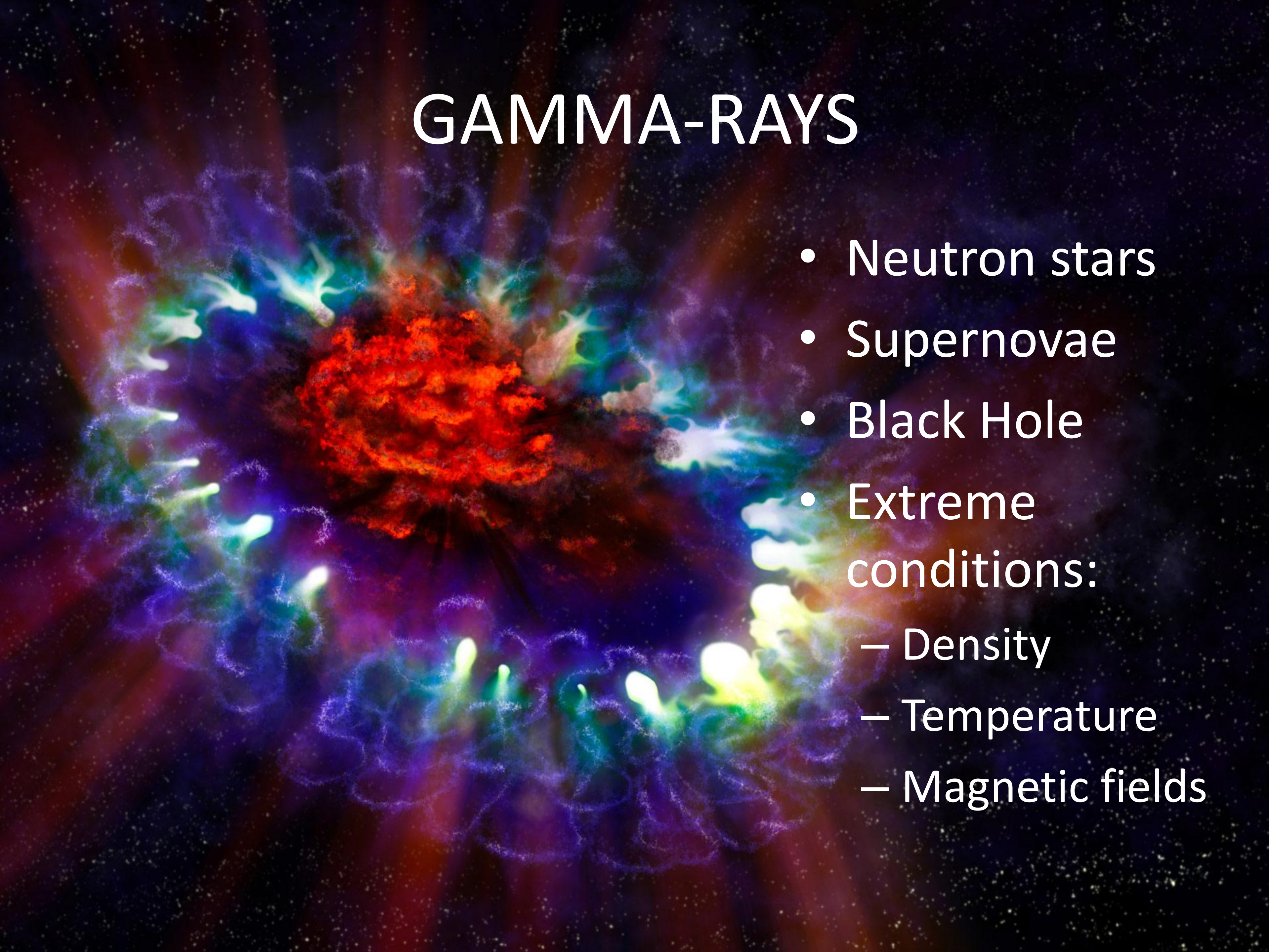


Figure 3. The limits for optical in apparent magnitude (green), radio flux density in mJy (red), and X-ray flux in erg cm^{-2} s^{-1} (blue) of our observations of the field of FRB 140514 from 8 telescopes that fully sampled the Parkes beam. Colors of data points refer to the axis scale of the same color. Light curves from GRB140512A (z = 0.725), 1.4 GHz radio data and $R-$band optical data for supernova SN1998bw (z ~0.008), $R-$band data for superluminous supernova SN2003ma (z = 0.289) and an $R-$band light curve for a typical type-Ia SN (z = 0.5) have been included for reference (Evans et al. 2007; Rest et al. 2011; Kulkarni et al. 2014; Galama et al. 1998).

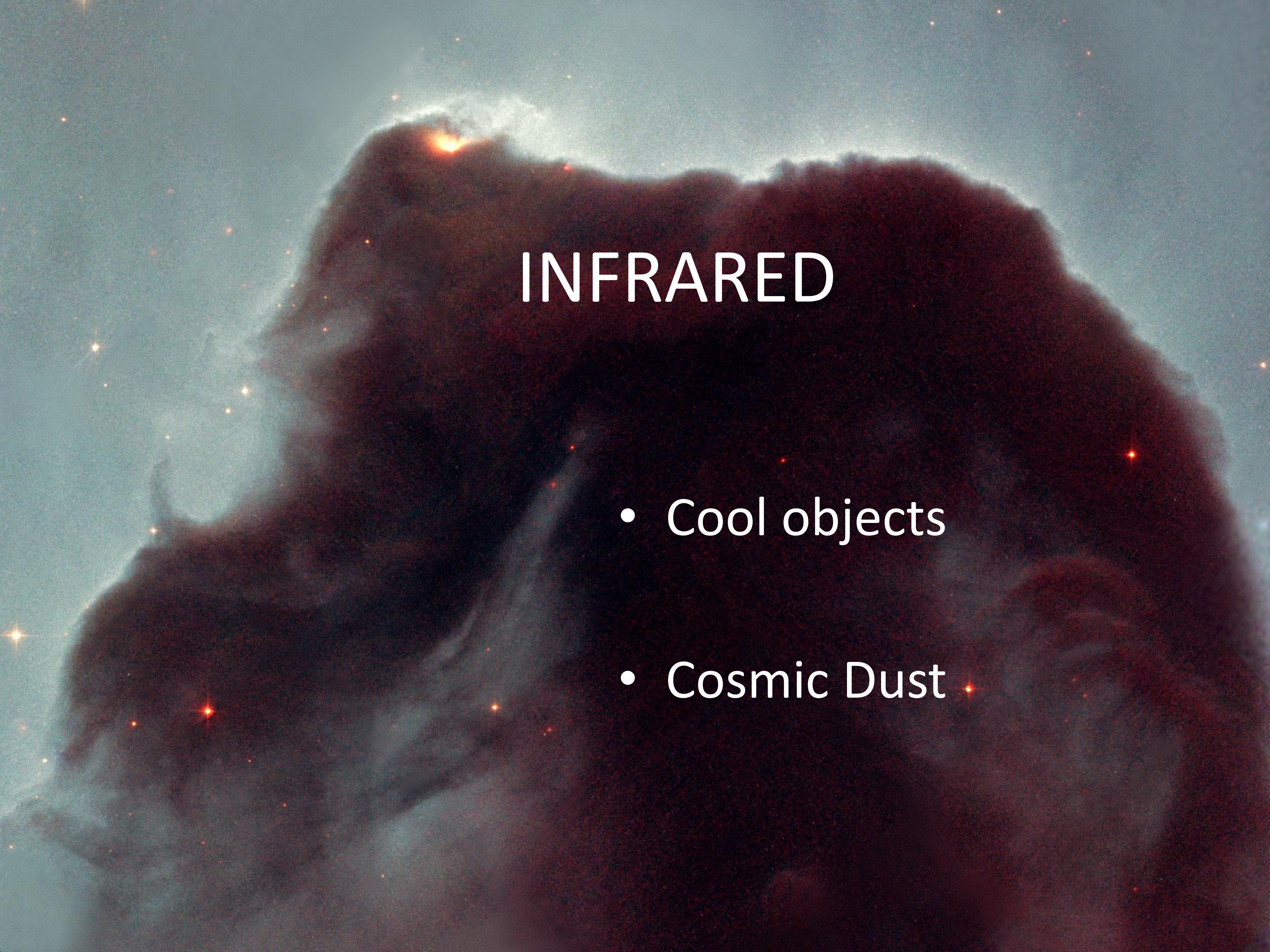

GAMMA-RAYS
• Neutron stars
• Supernovae
• Black Hole
• Extreme conditions:
– Density
– Temperature
– Magnetic fields

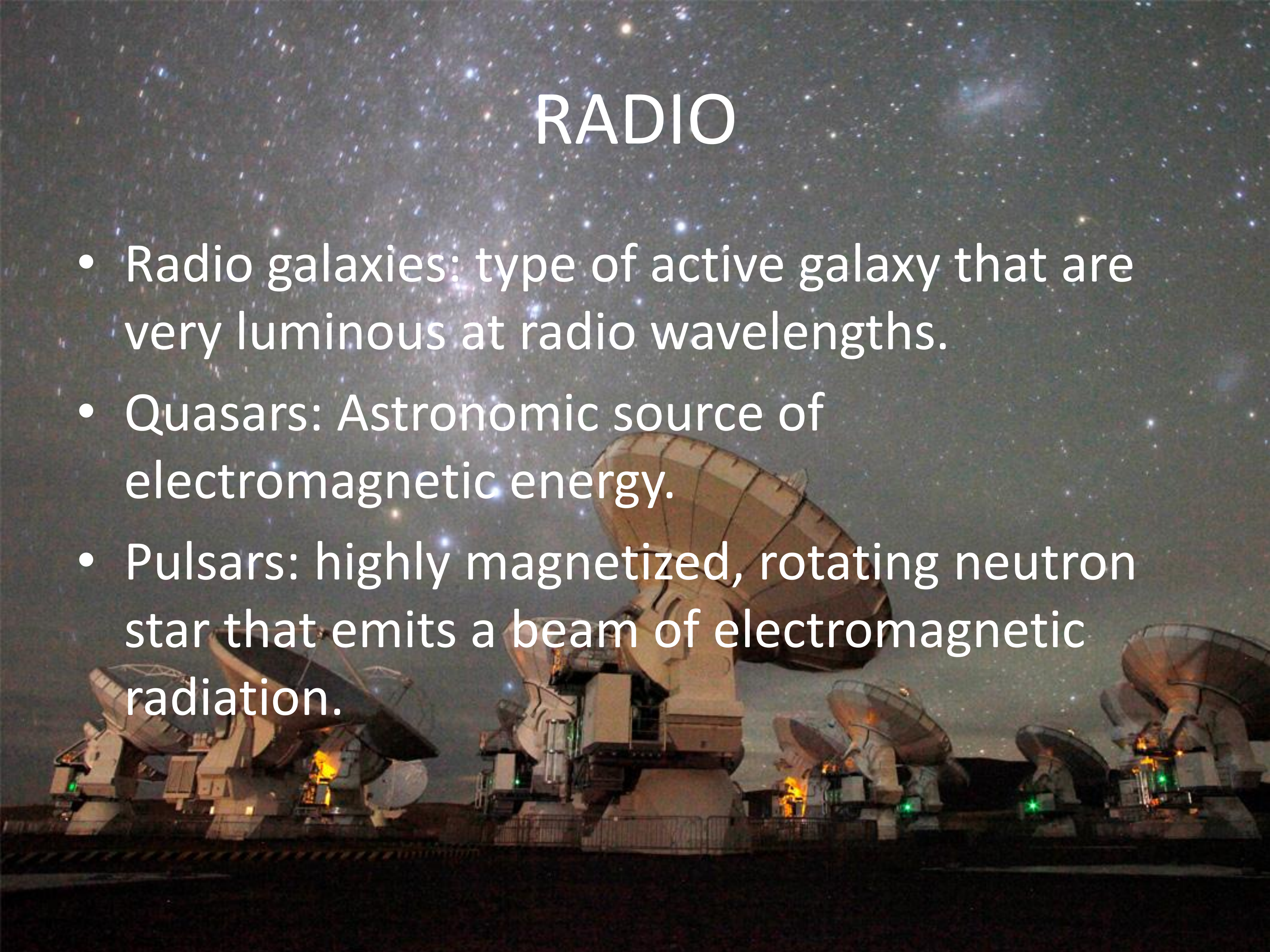
X-RAYS

- Surface of the planets
- Remains of Supernovae
- Neutron stars

VISIBLE LIGHT

- Photometry: Amount of light coming from an object.
- Spectrometry: Distribution of that light with respect to its wavelength
- Polarimetry: The polarisation state of that light.


INFRARED
• Cool objects
• Cosmic Dust

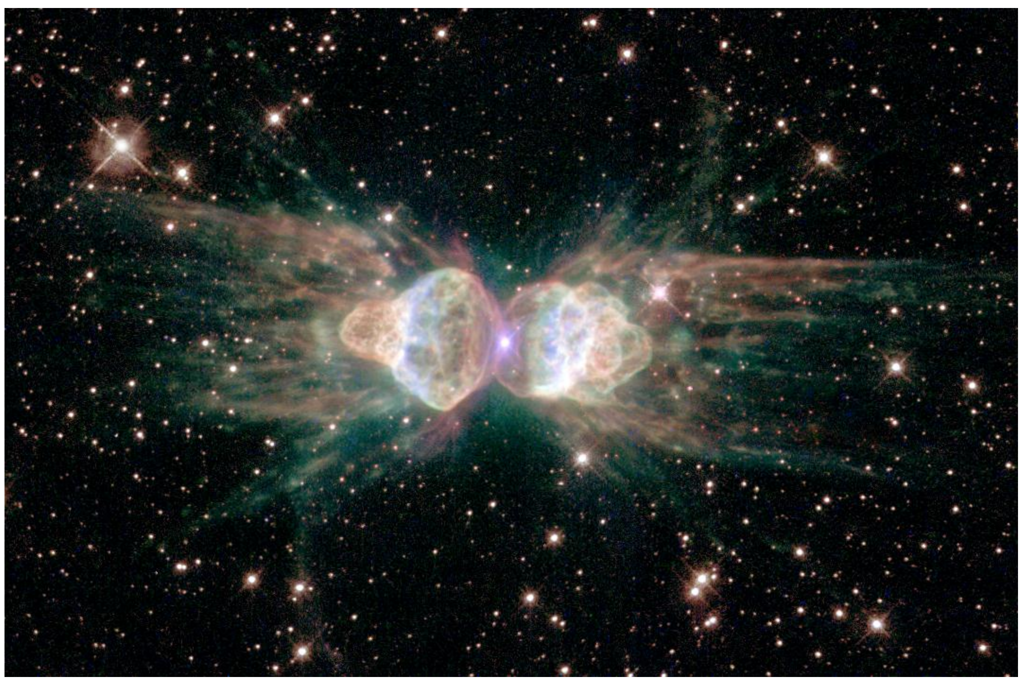


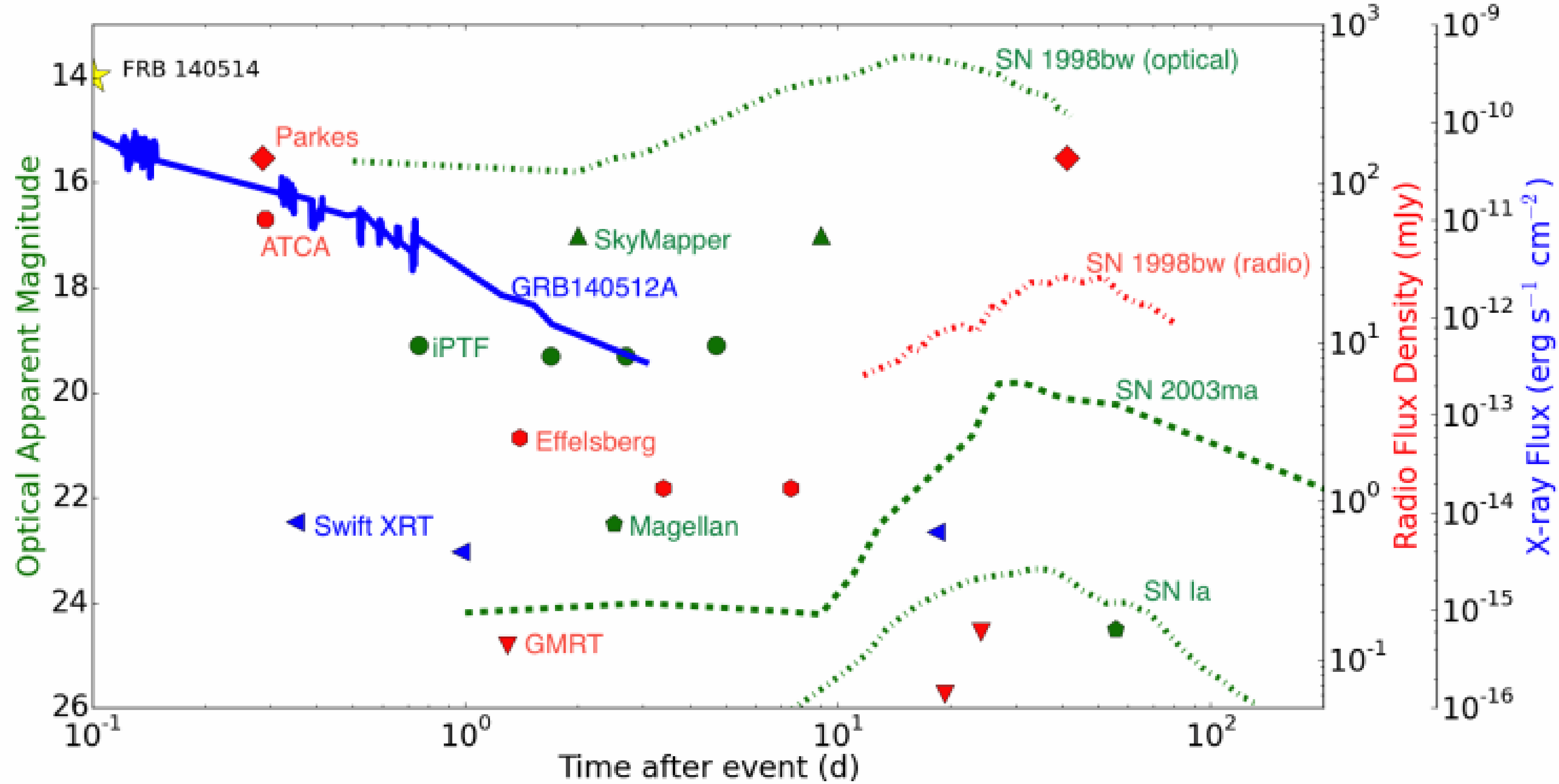
RADIO

- Radio galaxies: type of active galaxy that are very luminous at radio wavelengths.
- Quasars: Astronomic source of electromagnetic energy.
- Pulsars: highly magnetized, rotating neutron star that emits a beam of electromagnetic radiation.

WHY DIFFERENT WAVELENGTHS?

- Identify astronomical phenomena.
- It helped the scientist eliminate a couple of candidates: gamma-ray burst and supernovae.





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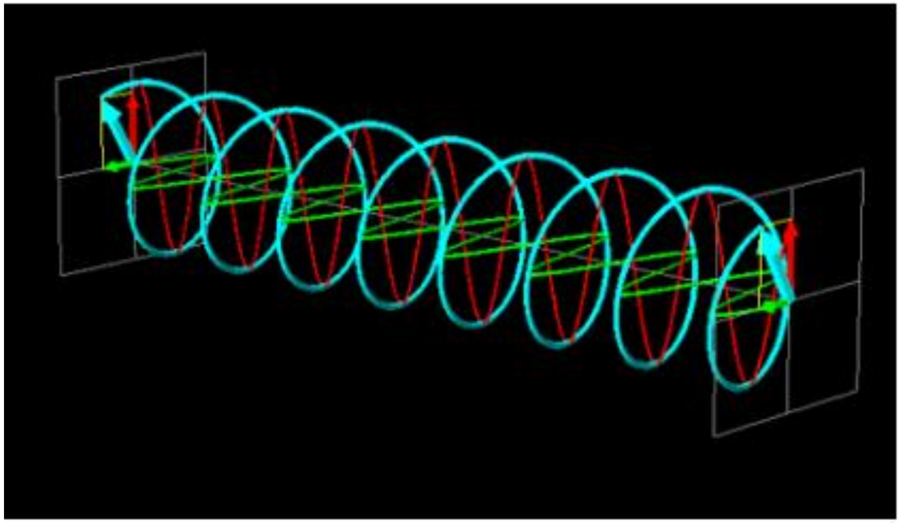
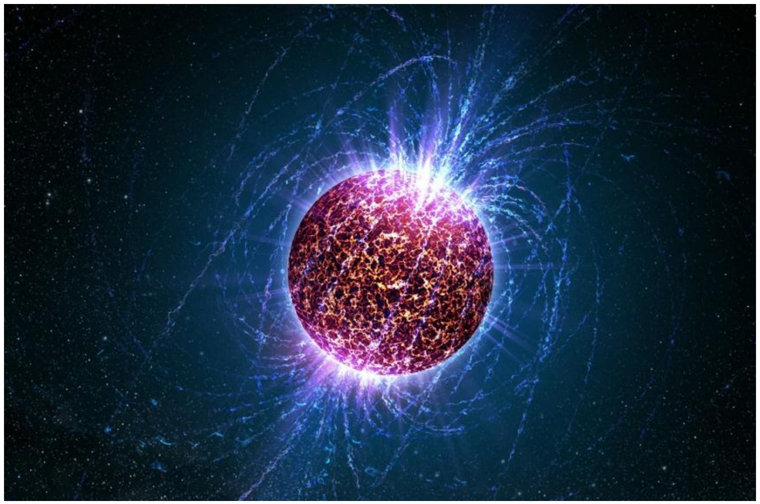
POLARISATION



*Polarisation is the direction in which electromagnetic waves oscillate.

- The signal from the radio wave burst was more than 20 percent circularly polarised and it suggests that there is a magnetic field in the vicinity that aligned the waves in particular directions.

NEUTRON STAR OR BLACK HOLE



- Quasars
- Extremely compact object
- Magnetic field