September 1, 2010

Reading assignment, Cosmic Catastrophes, Chapter 6 plus Section 5.1, Section 1.2.4 and Section 2.3 for background

Last lecture posted as pdf on class web site

Astronomy in the News? House threatens to cut funds for NASA science. 14 Nobel Prize winners, some astronauts, former NASA officials, 30 total, signed a letter in favor of President Obama's proposed space program, altering plans of previous administration.

Pic of the Day – Earth and Moon from perspective of Messenger satellite orbiting Mercury

Electronic version of Cosmic Catastrophes

No limit to access through UT library by means of UT eid and password (go to UT library online, search for Cosmic Catastrophes, click on "electronic resource")

Downloads and printing are limited to 20% of the content.

Quantum Pressure -- just depends on squeezing particles,
electrons for white dwarf, to very high density
-- depends on density only
-- *does not* depend on temperature

Important Implication:

Normal ★ Radiate energy, pressure tries to drop, star contracts and gets **hotter** (and higher pressure)

White Dwarf Radiate energy, *temperature does not matter*, pressure, size, remain constant, star gets **cooler**

Opposite behavior

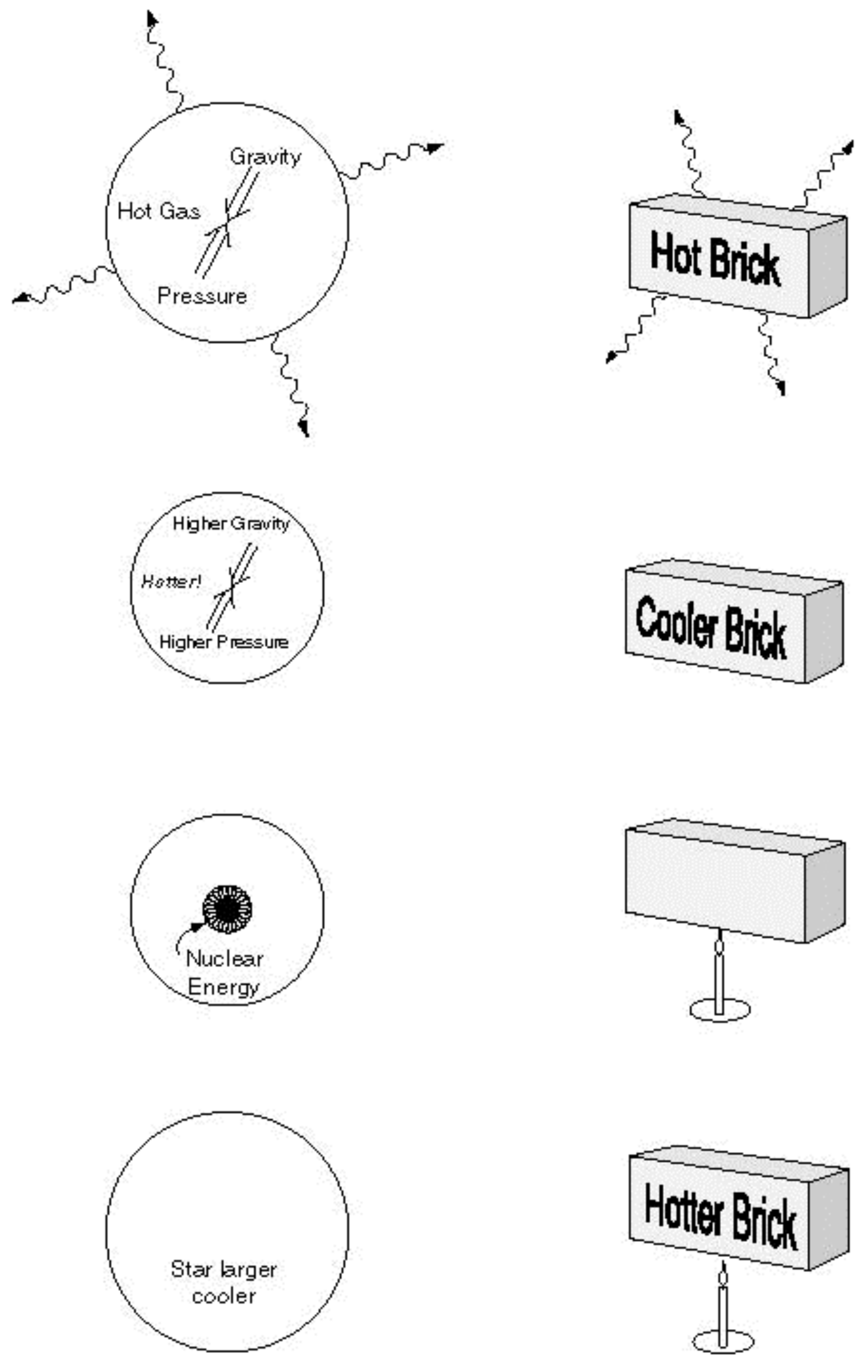
Normal Star - *Regulated*	put in energy, star expands, cools
White Dwarf - *Unregulated*	put in energy, hotter, more nuclear burning -- explosion!

Figure 1.3

A normal star can and will radiate away thermal energy and hence structural energy.

A brick cannot radiate its structural energy,

A white dwarf cannot radiate away its quantum energy.



A normal star supported by thermal pressure regulates its temperature. If excess energy is lost, the star contracts and heats. If excess energy is gained, the star expands and cools. Feedback loop, akin to the furnace, thermostat in your house.

A white dwarf, supported by the quantum pressure, cannot regulate its temperature. If excess energy is lost (the case for the vast majority of white dwarfs), they just get cooler. If Excess energy is gained, they heat up and can explode.

Behavior of white dwarf, Quantum Pressure, worked out by S. Chandrasekhar in the 1930's

Limit to mass the Quantum Pressure of electrons can support

Chandrasekhar limit ~ 1.4 $M_\odot$

density ~ billion grams/cc ~ 1000 tons/cubic centimeter

Maximum mass of white dwarf.

If more mass is added, the white dwarf must collapse or explode!

One Minute Exam

If nuclear reactions start burning in an ordinary star like the Sun, what happens to the temperature?

- The temperature goes up
- The temperature remains constant
- The temperature goes down
- Insufficient information to answer the question

One Minute Exam

If nuclear reactions start burning in a white dwarf, what happens to the temperature?

➡ The temperature goes up

⬅ The temperature remains constant

⬆ The temperature goes down

⬇ Insufficient information to answer the question

SUPERNOVAE

Catastrophic explosions that end the lives of stars,

Provide the heavy elements on which planets and life as we know it depends,

Energize the interstellar gas to form new stars,

Produce exotic compact objects, neutron stars and black holes,

Provide yardsticks to measure the history and fate of the Universe.

Reading:

Chapter 6 Supernovae

Also § 2.1, 2.2, 2.4 & 2.5 for background

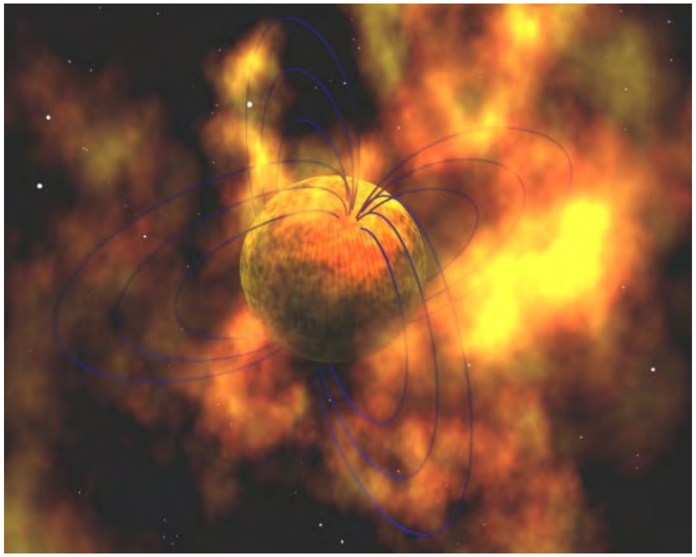
Issues to look for in background:

Why is it necessary for a thermonuclear fuel to get hot to burn - charge repulsion § 2.1 & 2.2

Core Collapse § 2.4 & 2.5

One type of supernova is powered by the ***collapse*** of the core of a massive star to produce

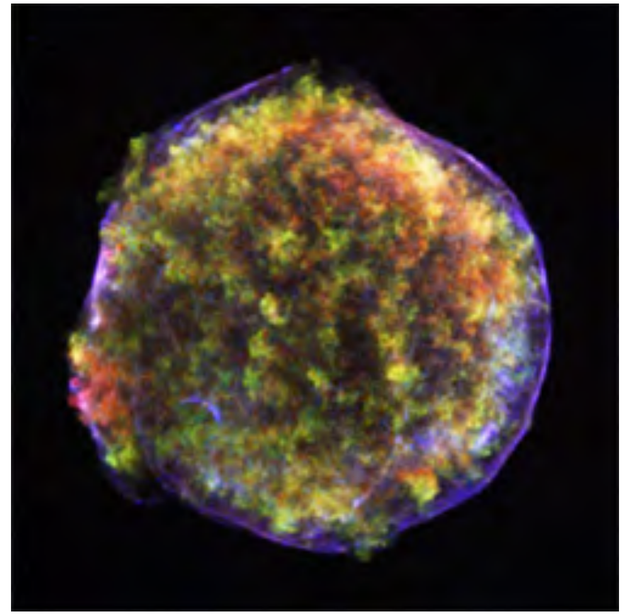
a ***neutron star***, or perhaps a ***black hole***

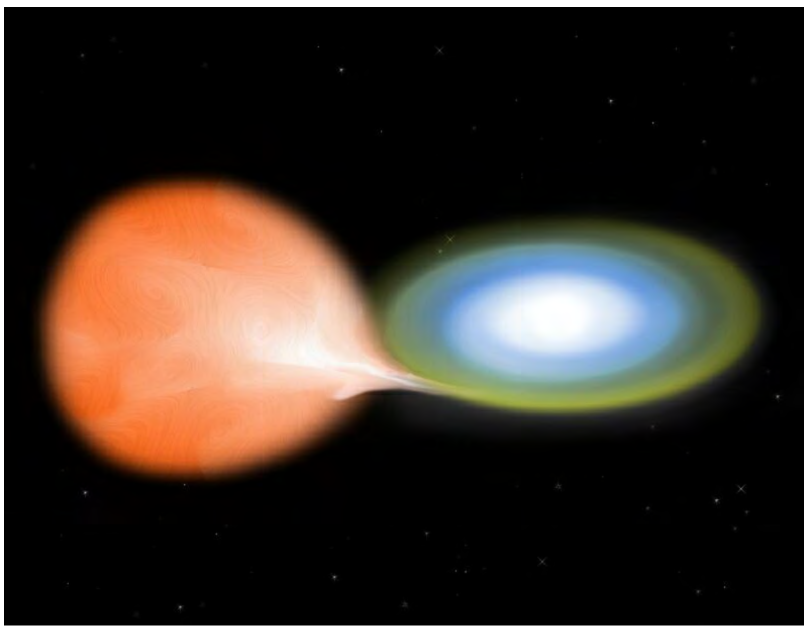


The mechanism of the explosion is still a mystery.

The other type of supernovae (Type Ia) is thought to come from a white dwarf that grows to an explosive condition in a binary system.

Chandra X-ray Observatory image
Of Tycho's supernova of 1572



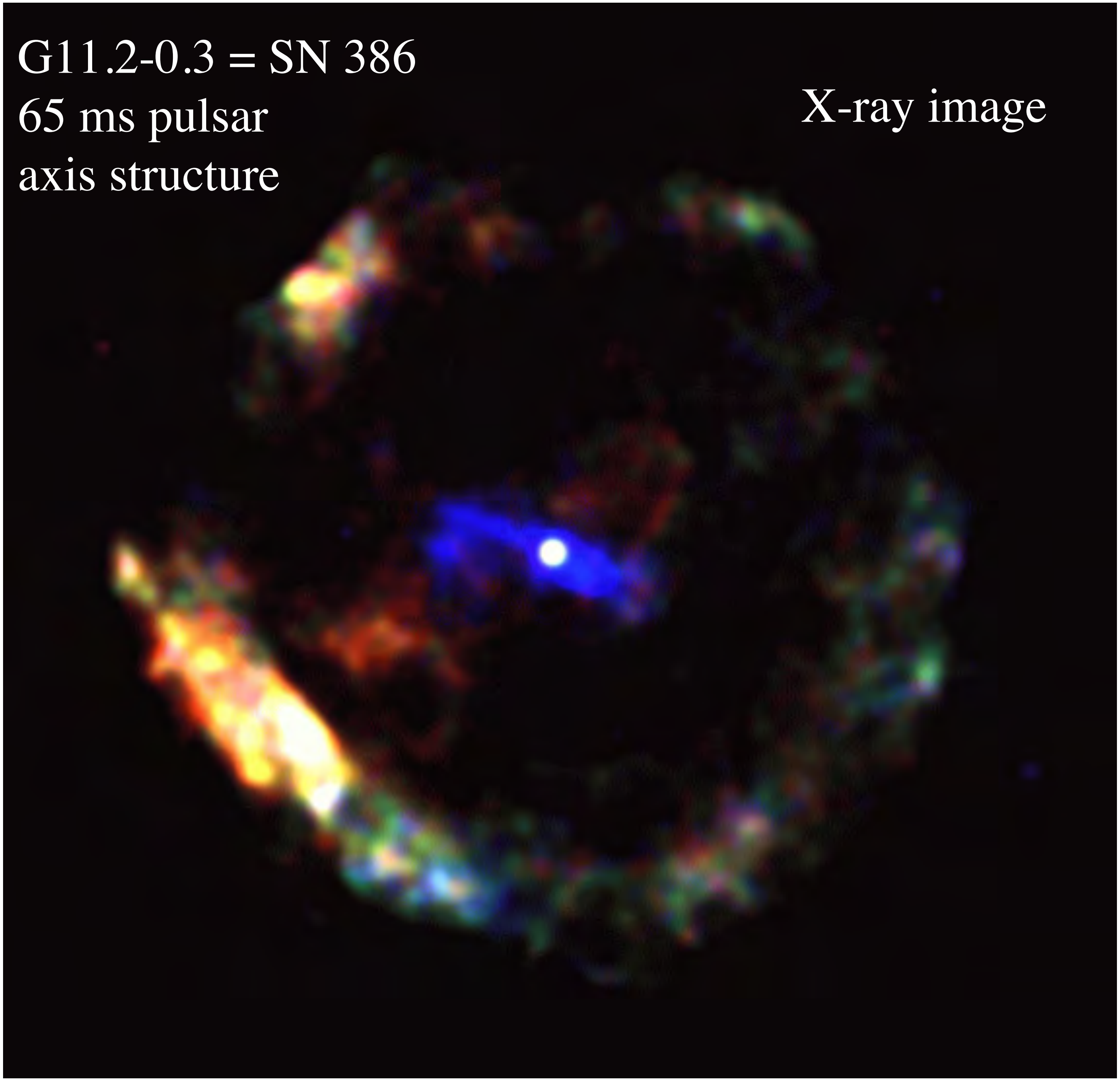


These explode completely, like a stick of dynamite, and leave no compact object (neutron star or black hole) behind.

Chapter 6 Supernovae

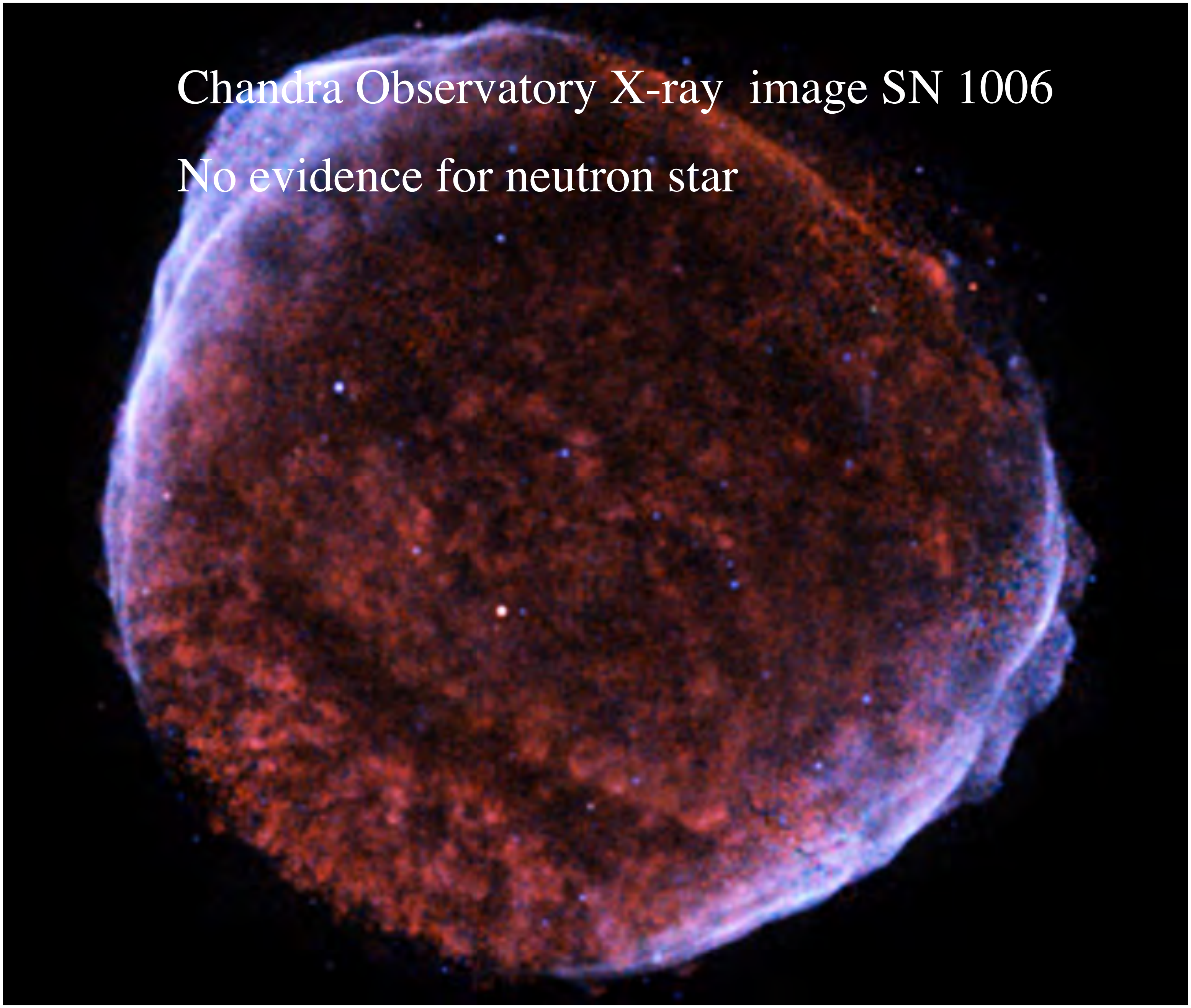
Historical Supernovae - ***in our Milky Way Galaxy*** observed with naked eye over 2000 years especially by Chinese (preserved records), but also Japanese, Koreans, Arabs, Native Americans, finally Europeans.

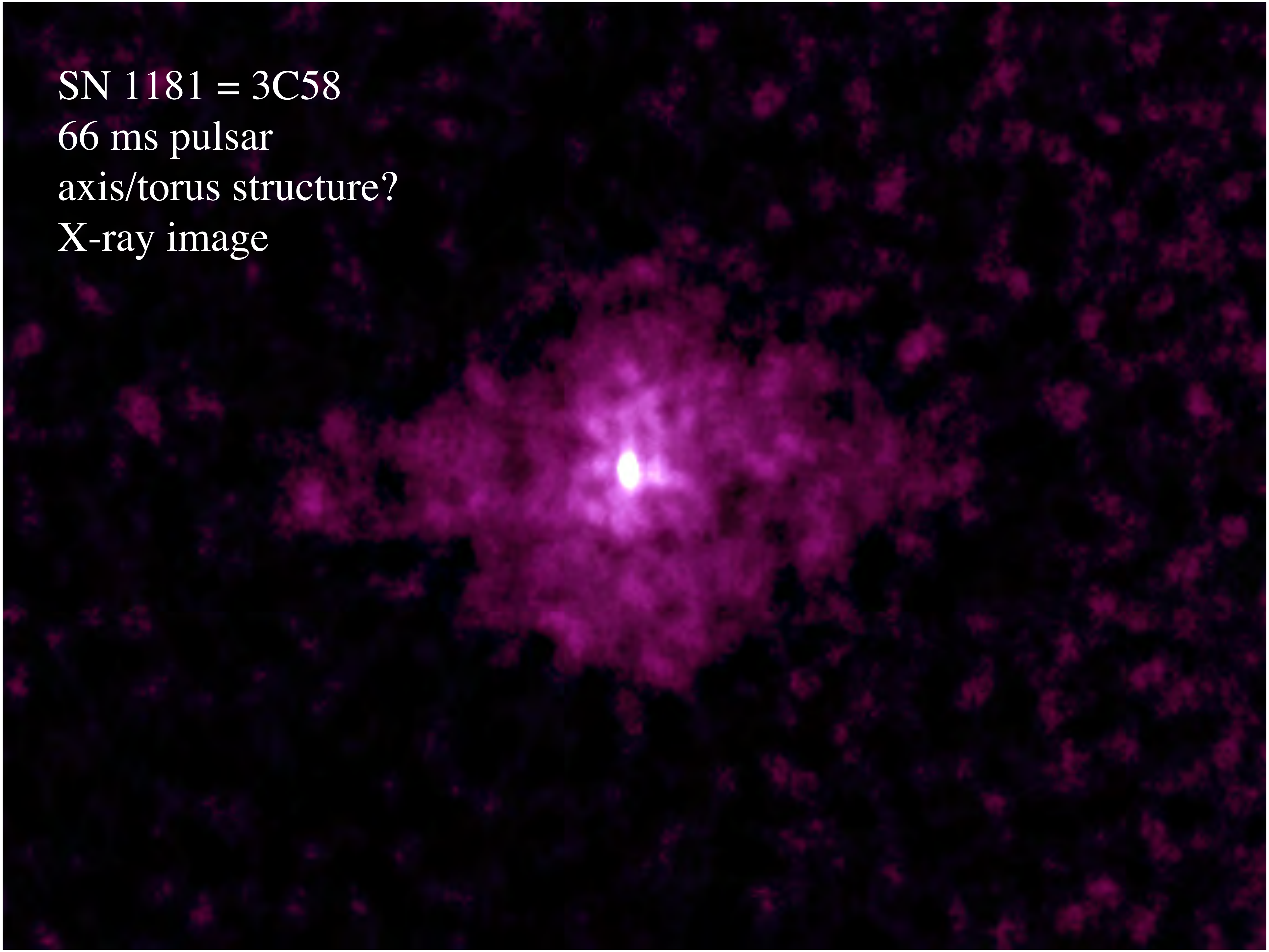
SN 386	earliest record	NS, jet?
SN 1006	brightest	No NS
SN 1054	Crab Nebula	NS, jets
SN 1181	(Radio Source 3C58)	NS, jets
SN 1572	Tycho	No NS
SN 1604	Kepler	No NS
~1680	Cas A	NS? jets
SN 1987A	nearby galaxy	NS? jets
Vela	10,000 years ago	NS, jets


G11.2-0.3 = SN 386
65 ms pulsar
axis structure
X-ray image

Chandra Observatory X-ray image SN 1006

No evidence for neutron star



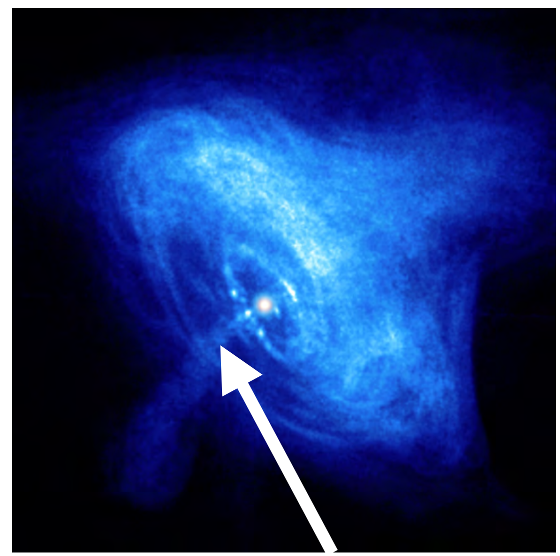

SN 1181 = 3C58
66 ms pulsar
axis/torus structure?
X-ray image

Crab Nebula

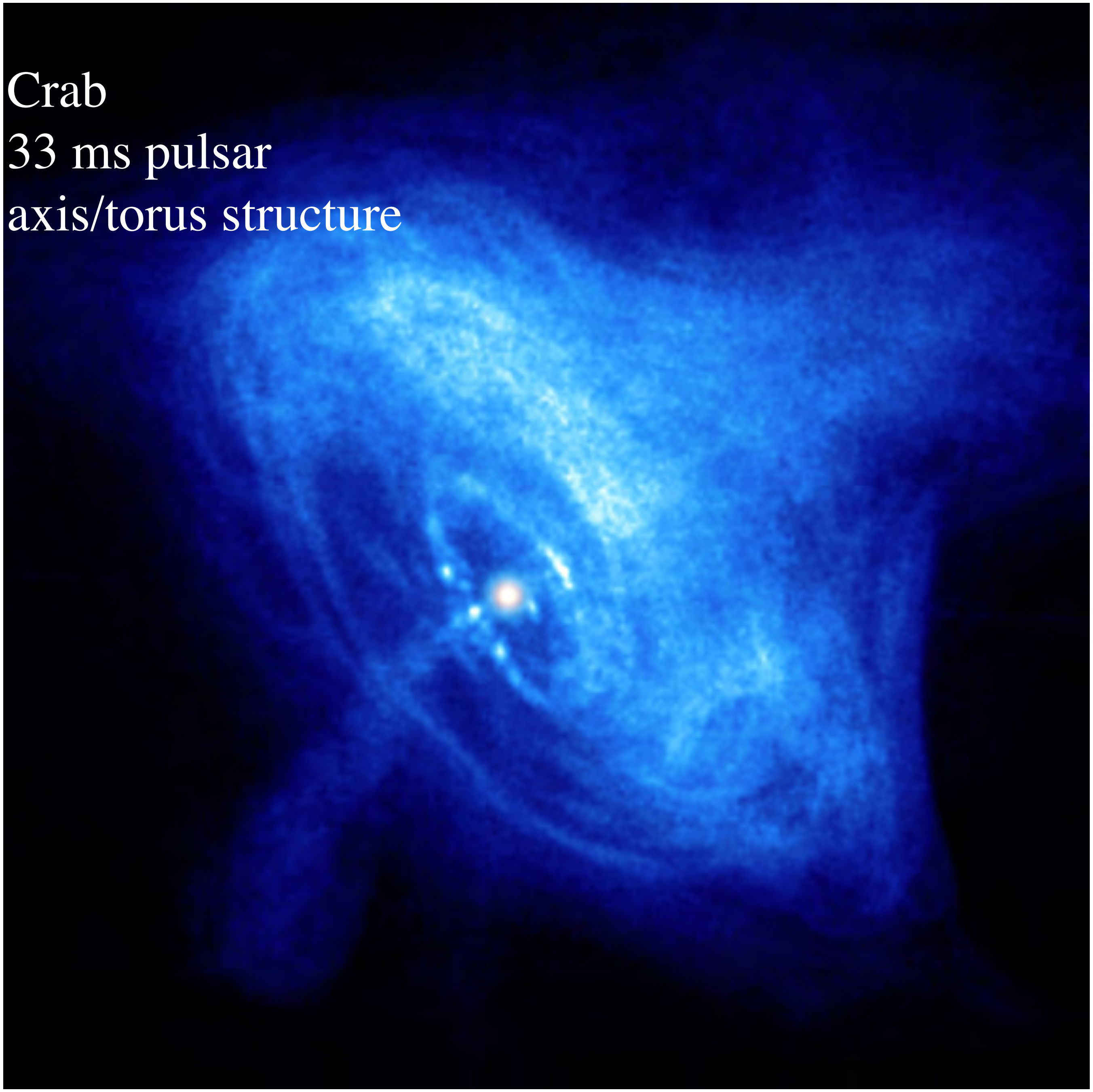
Remnant of “Chinese” Guest Star of 1054

Optical Image

Chandra Observatory
X-Ray Image



Left-over jet

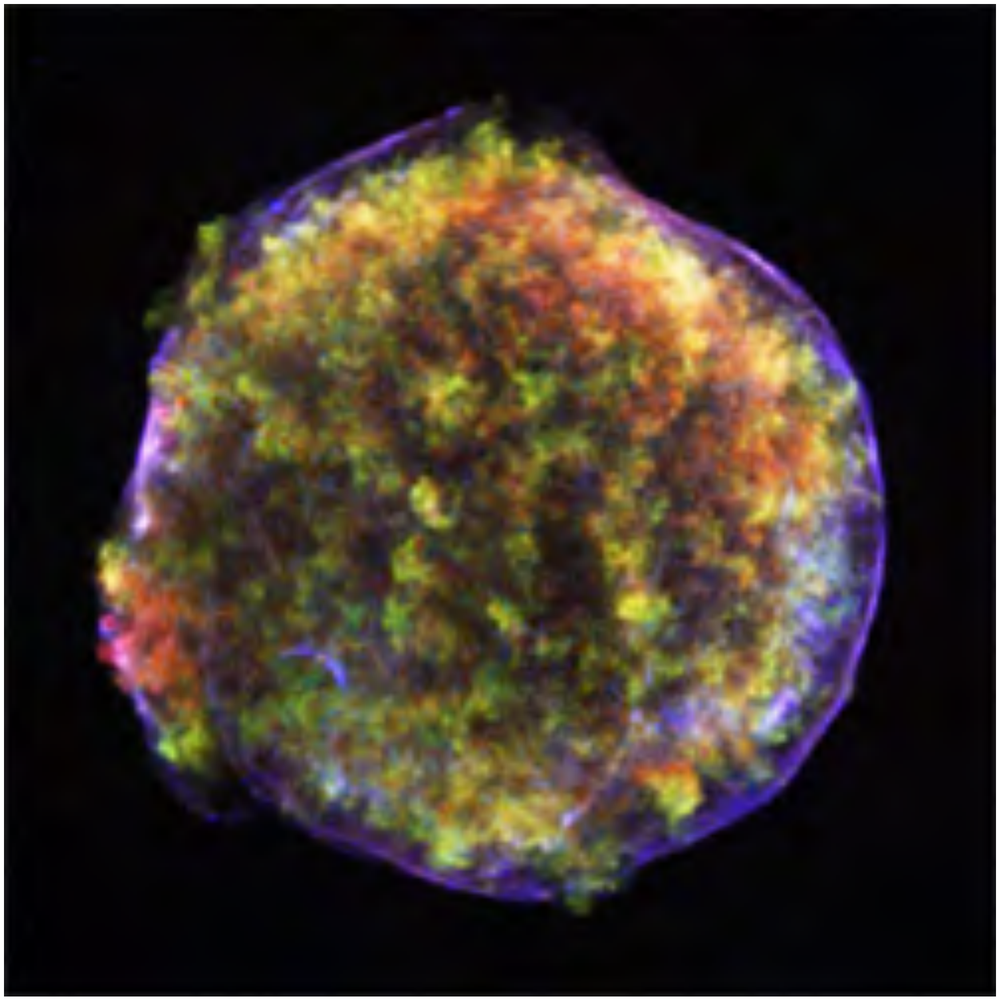

Crab
33 ms pulsar
axis/torus structure

Kepler

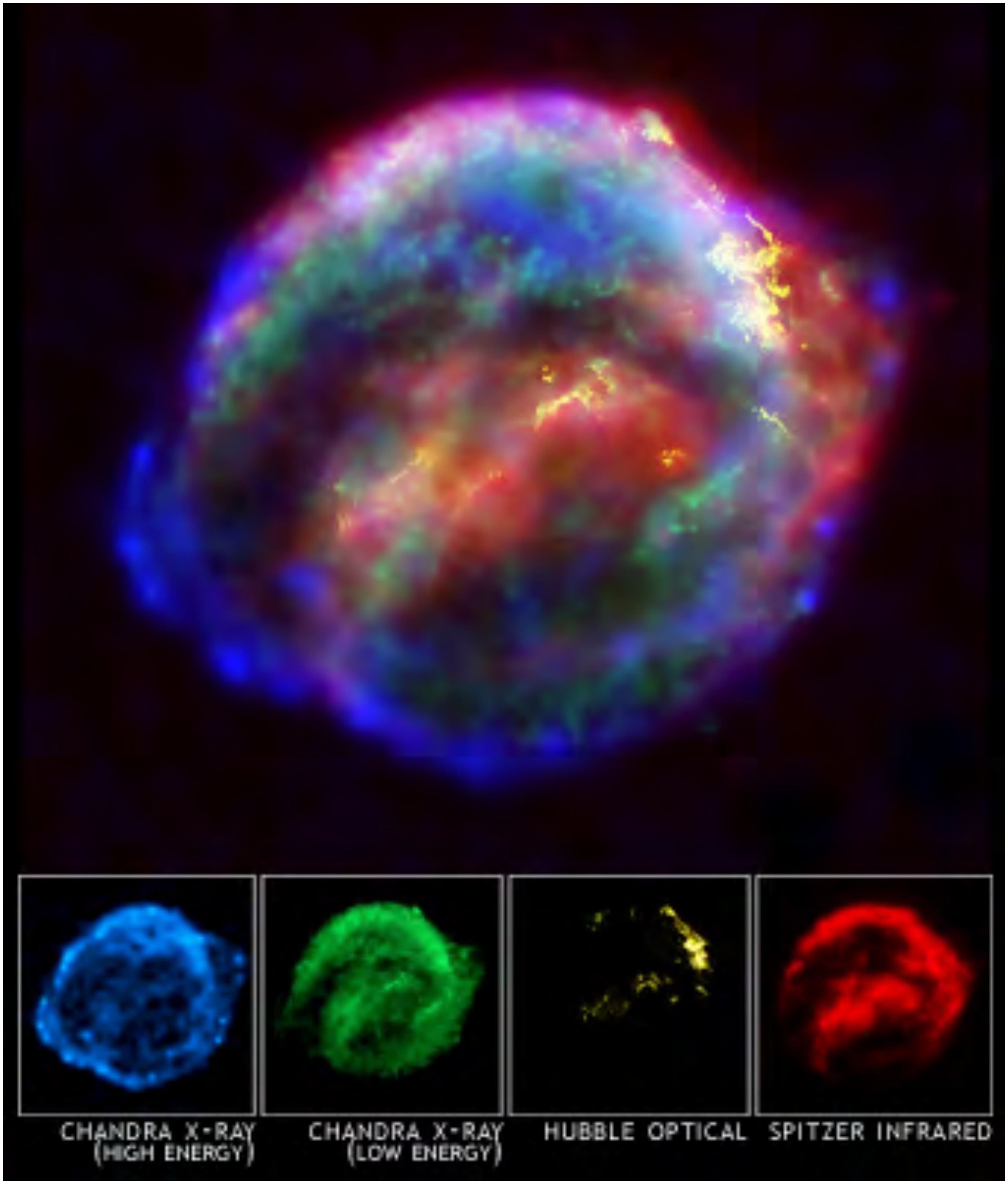
Tycho

Chandra Observatory X-ray Image of Tycho's Supernova of 1572

No evidence for neutron star



SN 1006

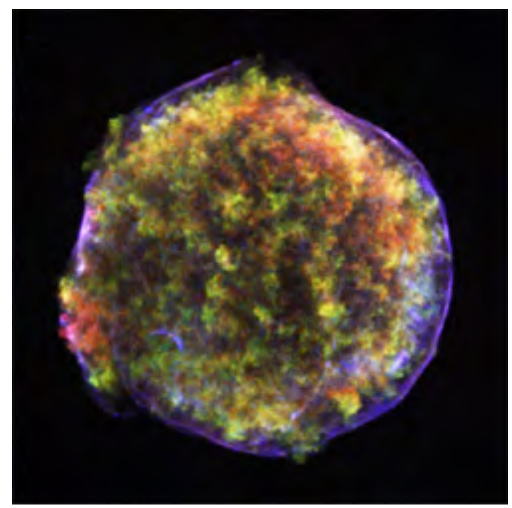


Great Observatories composite of Kepler's supernova 1604

No sign of neutron star

"sideways" alignment?

SN 1572 Tycho



Cassiopeia A by Chandra X-ray Observatory