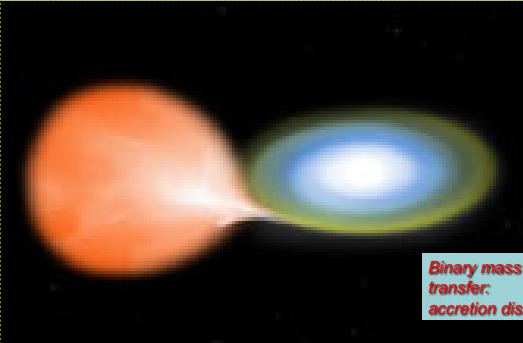


ASTR 1040: Stars & Galaxies



Binary mass transfer: accretion disk

Prof. Juri Toomre TAs: Piyush Agrawal, Connor Bice
Lecture 18 Thur 16 Mar 2017
zeus.colorado.edu/astr1040-toomre

Today and Tues


- Famous supernovae: **SN1987A + earlier**
- **Black holes**, their general properties, and their “**care and feeding**” – and **Mr. Einstein’s work** S.2 (special relativity), S.3 (general relativity)
- Overview read **Chap 19: ‘Our Galaxy’**
- New **HW # 9** (involves supernova energies + MA review), **HW #8 due today**
- **Observatory Night Tues March 21** (signup)
- **Second Mid-Term Exam** in class today

Clicker: What happens in a “white dwarf supernova” ?


- **A.** Carbon fuses throughout the white dwarf
- **B.** Hydrogen fuses on the surface of the white dwarf
- **C.** The white dwarf collapse into a neutron star
- **D.** Helium fuses throughout the white dwarf

Nearest: Story of SN 1987A in LMC

Large Magellanic Cloud (LMC)
(10,000 tiles with Spitzer composite IR)




24 Feb 1987: SN in LMC (160,000 ly away)



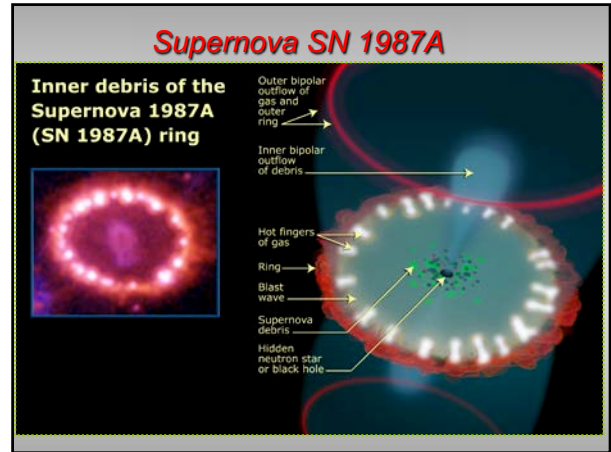
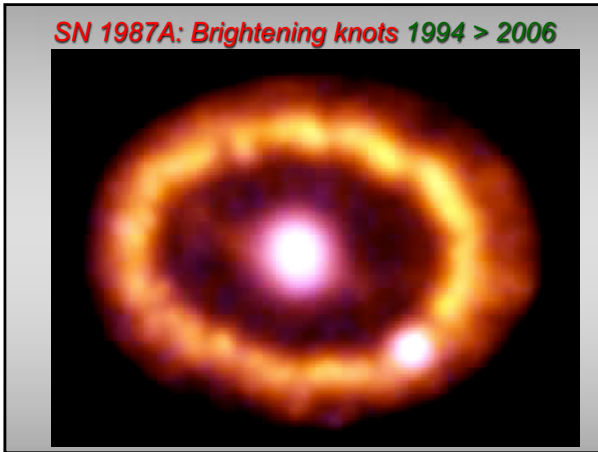
BEFORE
blue supergiant

AFTER (SN 1987A)

Mysterious triple rings in SN 1987A



20 year birthday picture (Chandra + HST)



SNR "numbers game"

SUPERNOVA REMNANTS (SNR)
 ... EXPANDING DEBRIS OF EXPLOSION
 DO NOT LAST VERY LONG BEFORE DISSIPATING

- FOR ABOUT 3000 YEARS, SEEN IN X-RAY, VISIBLE, RADIO
- AFTER ~ 50,000 YRS, SHOCK WAVE SHARPENS MATERIAL AROUND, BUT GAS HAS COOLED → RADIO EMISSION ABANDON
- PROBABLY INVISIBLE AFTER ~ MILLION YEARS

BUT ... SUPERHELLES
 CAUSED BY SUCCESSIVE SN IN THE PROXIMITY MAY LAST MUCH LONGER!

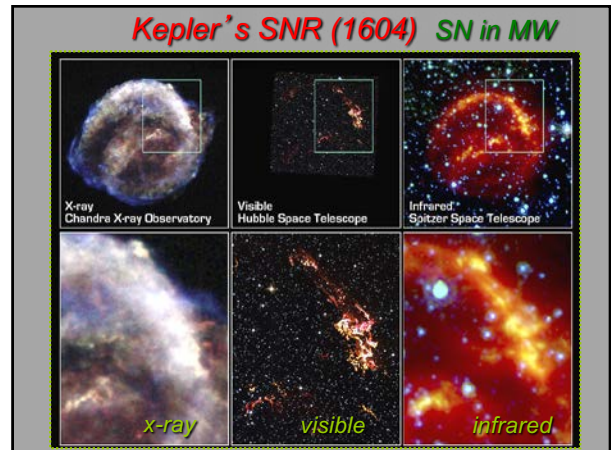
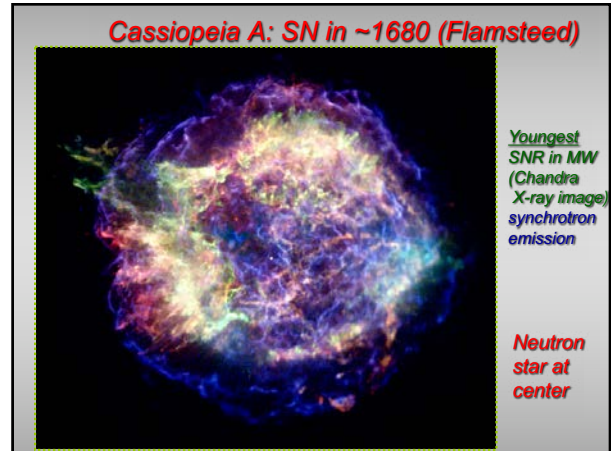
THE NUMBERS GAME:

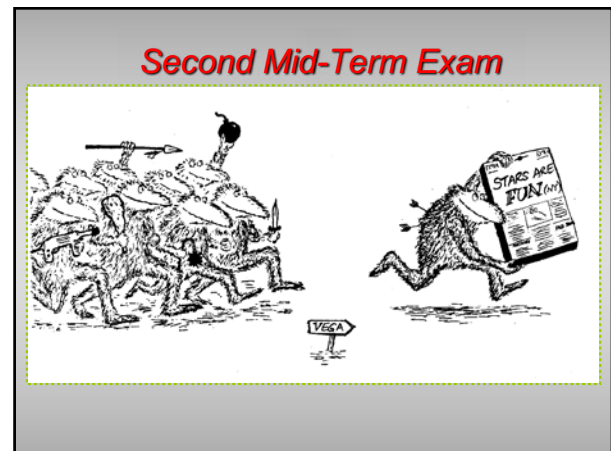
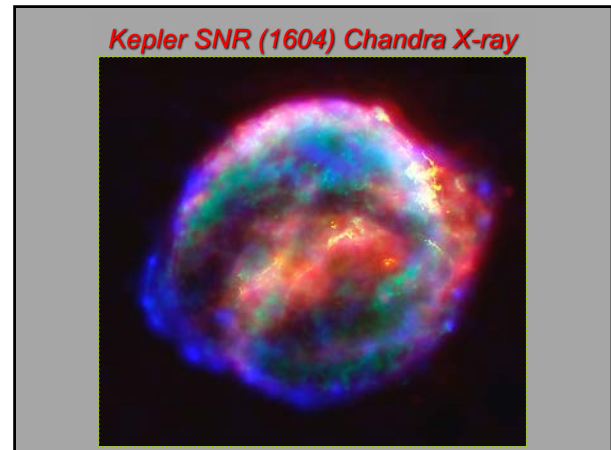
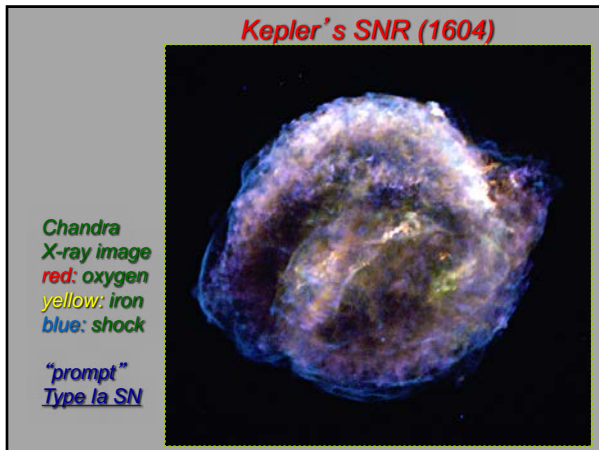
- ~ 120 SNR DETECTED IN OUR GALAXY (MUCH IN RADIO)
- 5 HAVE IDENTIFIABLE PULSARS
- ~ 50 SNR IN LMC
- ~ 10 SNR IN SMC

BUT ~ 400 PULSARS FOUND
 IN OUR GALAXY, ± IN LMC

ANSWER: PULSARS BEING BORN
 (~ 4 MY), PROBE MOTION OF PULSAR MAY CAREY IF AWAY FROM SNR

Cygnus Loop





Rules of the Game

- Closed book, closed notes, can use double-sided handwritten "crib sheet"; 50 minutes
- **Print your name and student ID on top of pages 1 and 6 of exam sheets**
- **Print and encode your name and student ID on scan sheet (and nothing else)**
- Use # 2 (soft) pencil for marking your answers on scan sheet (\$ 1 buys you a pencil !)
- **Respond carefully to Essay Question 47 with full and lucid sentences (and detailed sketch)**