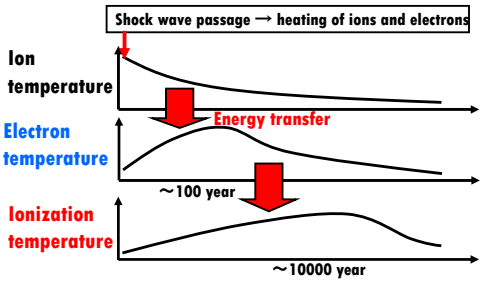
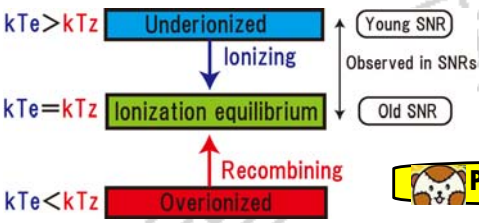
Suzaku Discovery of Strong Recombination Structures from the SNR W49B

○ Midori Ozawa (Kyoto Univ), Katsuji Koyama, Hiroya Yamaguchi, Kuniaki Masai, Toru Tamagawa

We have discovered strong recombination X-rays from the SNR W49B.
This finding would provide new insight into SNR evolution.

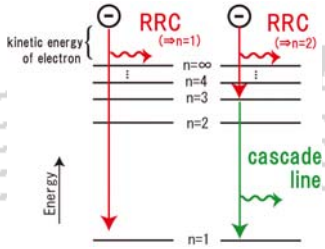
Common knowledge of SNR plasma





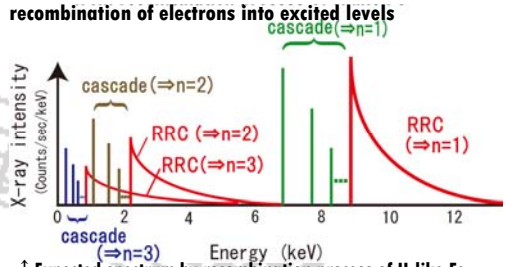
★**Two Important Temperatures**

- **Electron temperature (kTe)**
  →Indicate kinetic energy of electrons
- **Ionization temperatures (kTz)**
  →Indicate ionization degree of ions



★**"If" there is recombining plasma, we would see…**

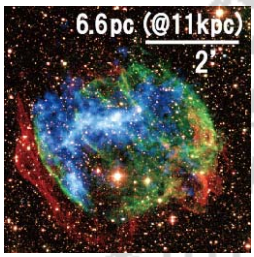
- **Radiative recombination continuum (RRC)**
  →Free-bound emission of electrons
- **Cascade lines**
  →Bound-bound emission followed by recombination of electrons into excited levels



↑ Expected spectrum by recombination process of H-like Fe

Previously known SNRs all exhibit ionizing and underionized (kTe > kTz) state.

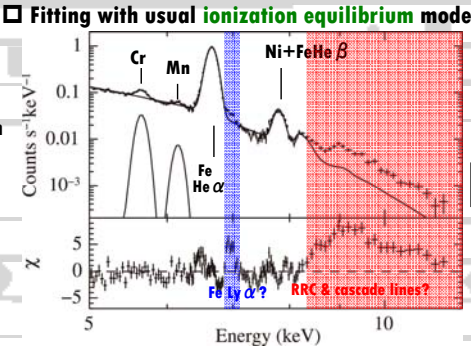
Suzaku Observation of W49B



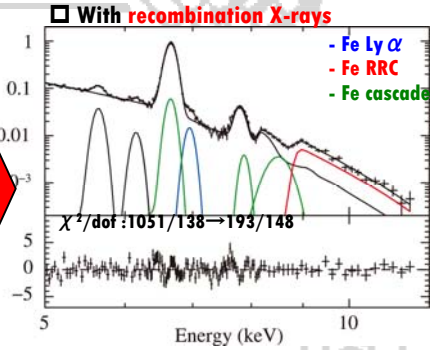
- **Suzaku XIS**
  -High energy resolution
  -Low and stable BGD
  -Large effective area

Blue: X-ray {Chandra}
Green:Infrared [FeII]
Red: Infrared (H_2)
(Keohane et al. 2007)

- **Fitting with usual ionization equilibrium model**

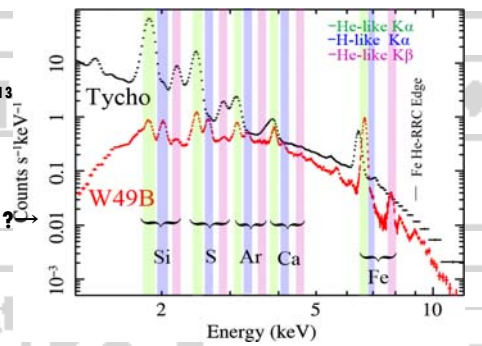


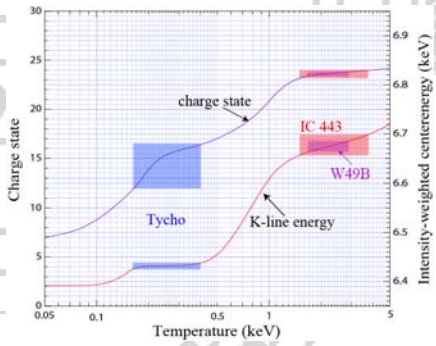
- **With recombination X-rays**



- **Deep (31 hour) observation**
- **XIS analysis from whole SNR region**
- **Strong RRC and cascade lines→Recombining plasma !**
- **kTe~1.5 keV & kTz~2.7 keV →overionized state !**
- **VEM= $\int n_e n_H dV / 4\pi D^2$ [cm^{-5}]**
  brems:1.61(1.60-1.62)×10^{13} / RRC: 1.3 (1.0-2.6)×10^{13}
  →Emission from single component !

Plasma is in strongly overionized and recombining state.





- **What is the spectral difference between W49B and "normal" ionizing SNR (Tycho) ?→**
  ✓**Strong recombination structures**
  ✓**Strong Ly α lines**
  ✓**High line center energies**

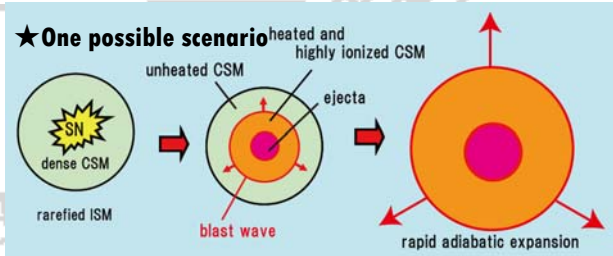
Origin of unusually strong recombination X-rays

★**Why low temperature electrons and highly ionized ions coexist ?**

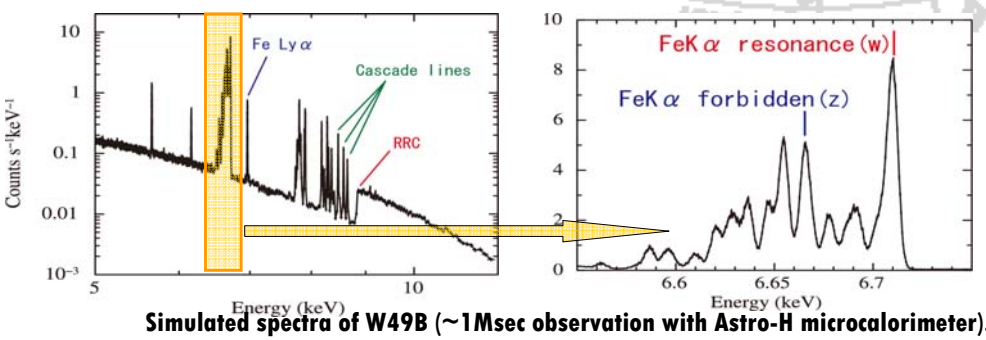
★**During evolution of SNRs,**
- **Electrons should have cooled down.**
  and/or
- **Ions should be highly ionized.**

★**Examples to accomplish such situations are,**
- **Adiabatic expansion or thermal conduction**
- **Photoionization**

★**One possible scenario**



What We See with Microcalorimeter onboard Astro-H ?



Simulated spectra of W49B (~1Msec observation with Astro-H microcalorimeter).

- **If recombination-dominant z:w~1:2**
- **If collisional-dominant z:w~1:8**

→We can discuss origin from fine structure!