# A03: Explosive Astrophysical Phenomena and Nucleosynthesis based on Quark Dynamics and Nuclear Structure


2011.12.3 @ Shima

Hideyuki Suzuki (Tokyo Univ. of Science)


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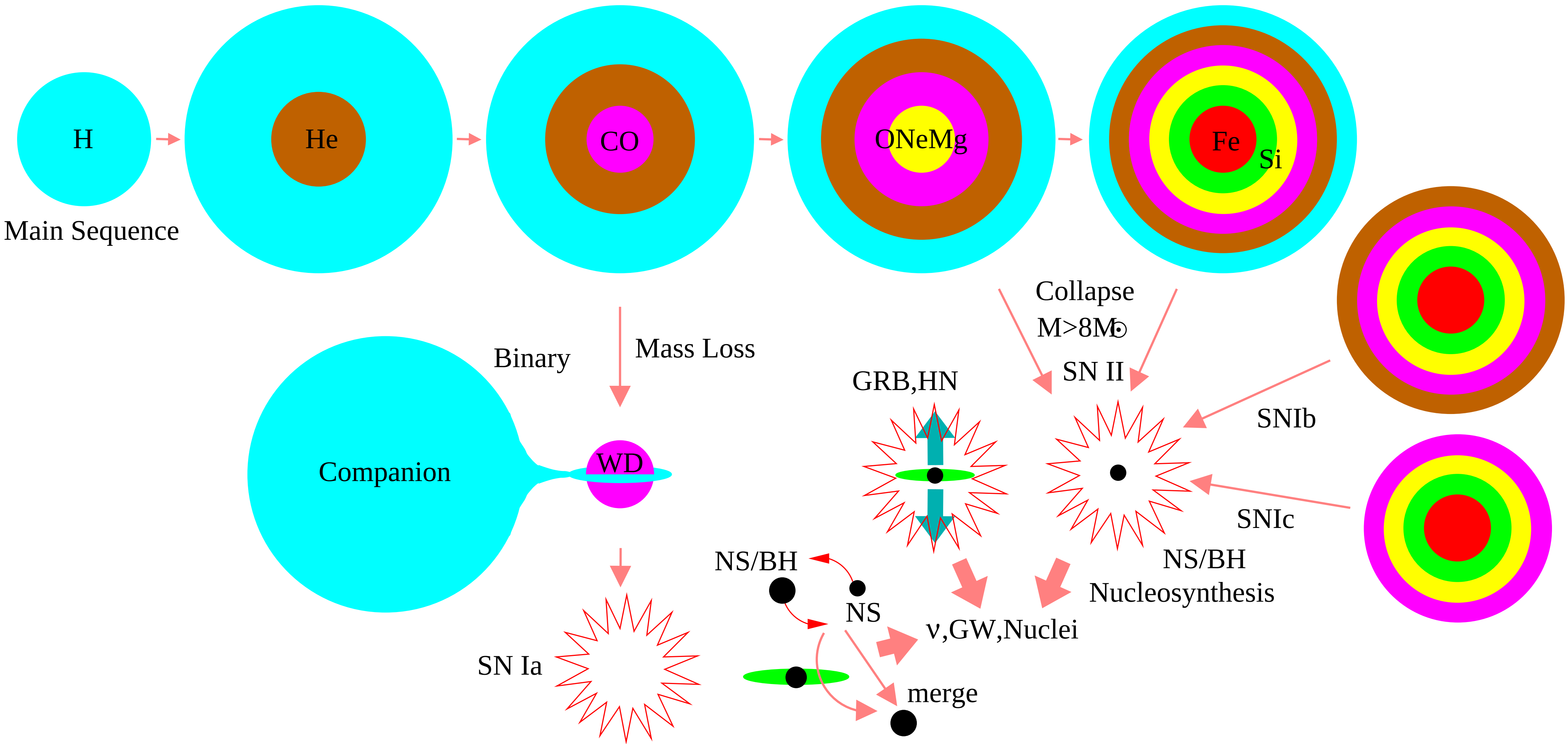
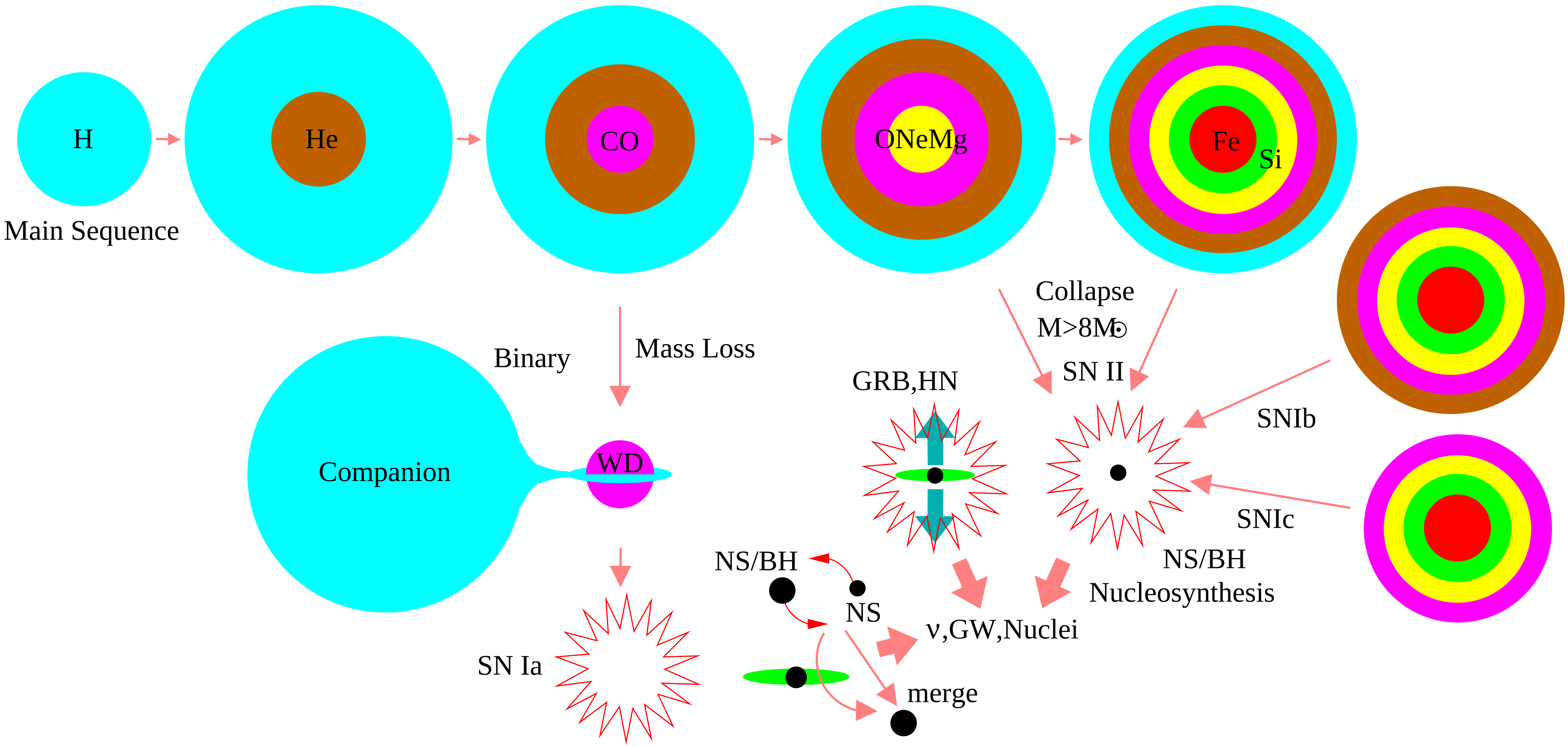
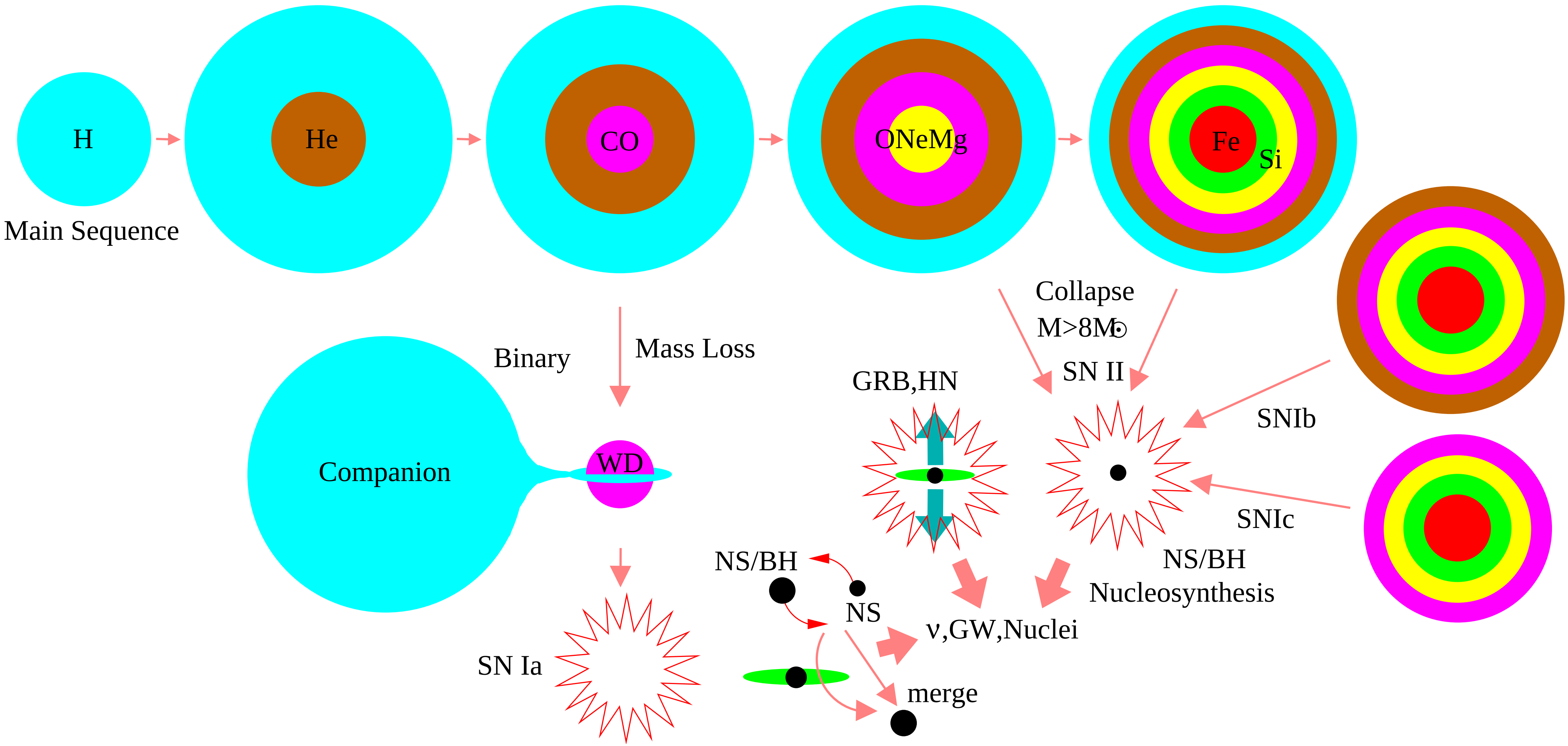
| Core Members | Hideyuki Suzuki (TUS)<br>Masaru Shibata (Kyoto, Numerical Relativity)<br>Toshitaka Kajino (NAO, Nuclear Astrophysics)<br>Kohsuke Sumiyoshi (Numazu, Supernova Simulation)<br>Hideyuki Umeda (Tokyo, Stellar Evolution, Nucleosynthesis) |
| Collaborators | Akira Ohnishi (Kyoto), Shoichi Yamada (Waseda),<br>Kohji Uryu (Ryukyu), Satoshi Chiba (JAEA),<br>Nobuyuki Iwamoto (JAEA), Takashi Yoshida (Tokyo)<br>Kazuhiro Oyamatsu (Aichi Shukutoku), Masatoshi Takano (Waseda) |
| PD | Ko Nakamura (NAO), Takashi Yoshida (Tokyo),<br>Chikako Ishizuka (TUS) |
| Grant | Tomoyuki Hanawa (Chiba), Ken-ichi Nomoto (IPMU),<br>Shigehiro Nagataki (Kyoto), Hajime Sotani (NAO) |



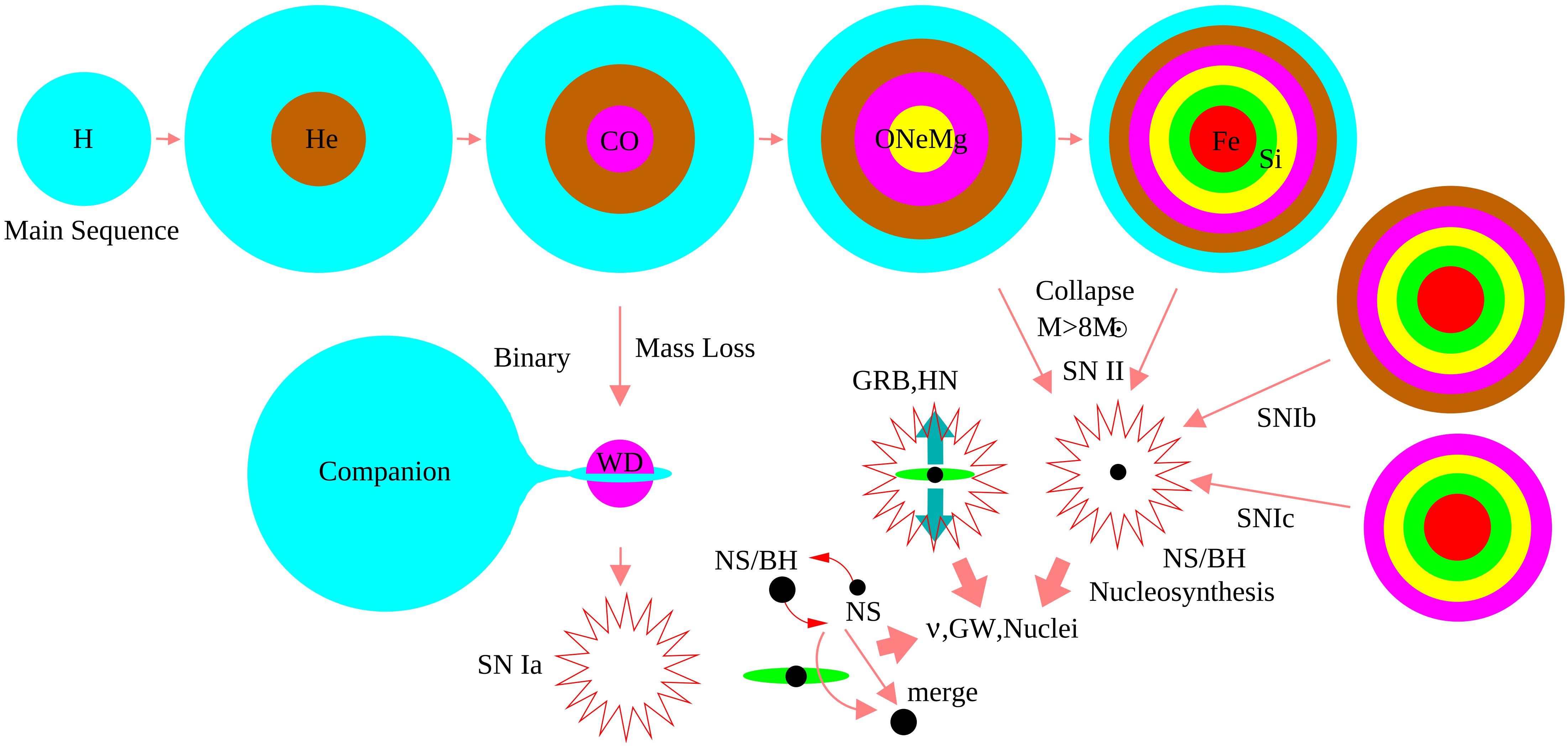

- Yoshida: Stellar Evolution of SN Progenitors and of Rotating Stars
- Umeda: Progenitors of ONeMg SNe
- Furusawa, Yamada: NSE EOS with multi species of nuclei
- Togashi, Yamamuro, Takano, Suzuki: SN EOS using the cluster variational method(collaboration with A02, A04)
- Ishizuka: towards an EOS database



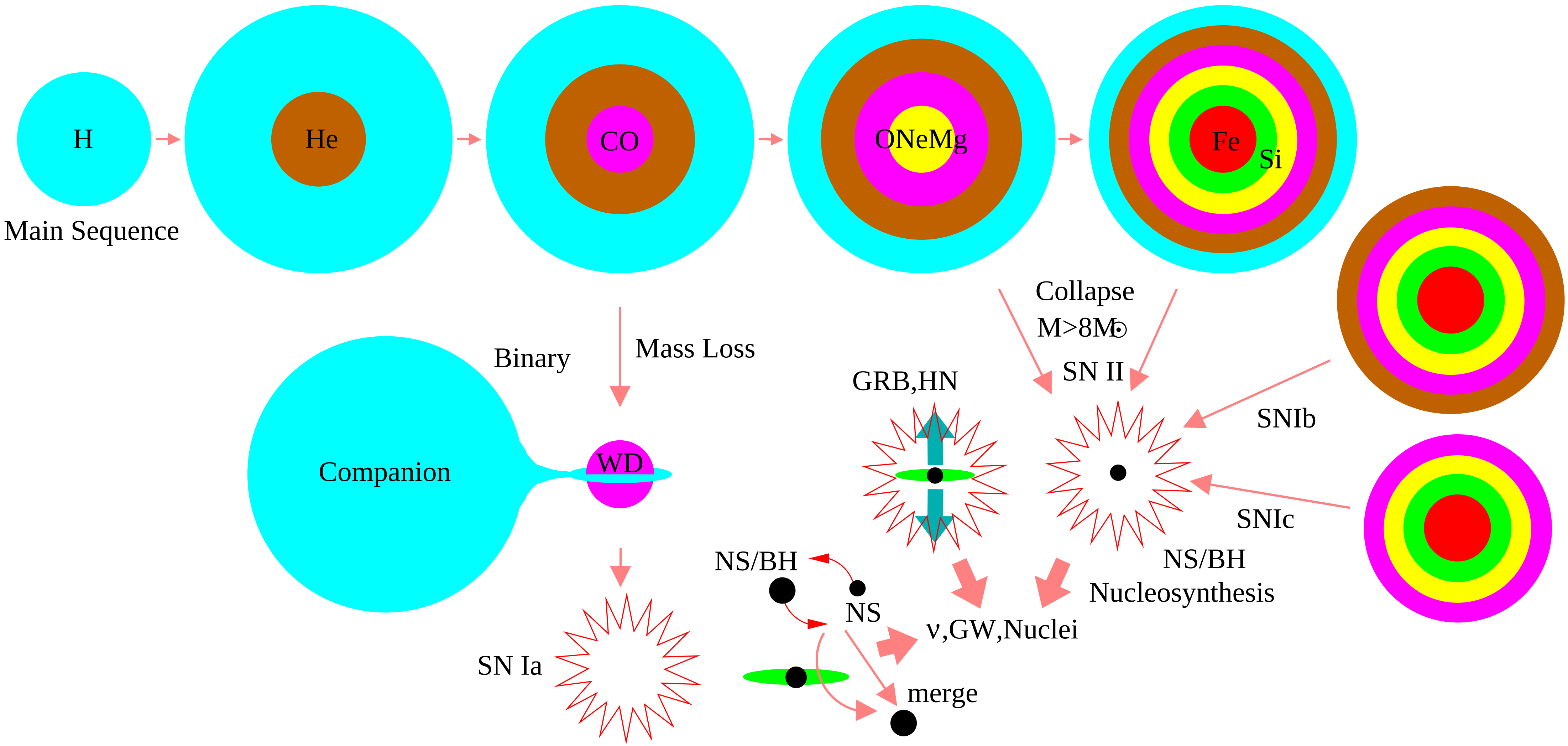

- Sekiguchi: Numerical Relativity with nuclear EOS + $\nu$(simulations of merger and collapsar models)
- Takiwaki, Suwa, Kotake: 2D/3D SN simulations
- Ohkita: aspherical explosion of massive CO stars



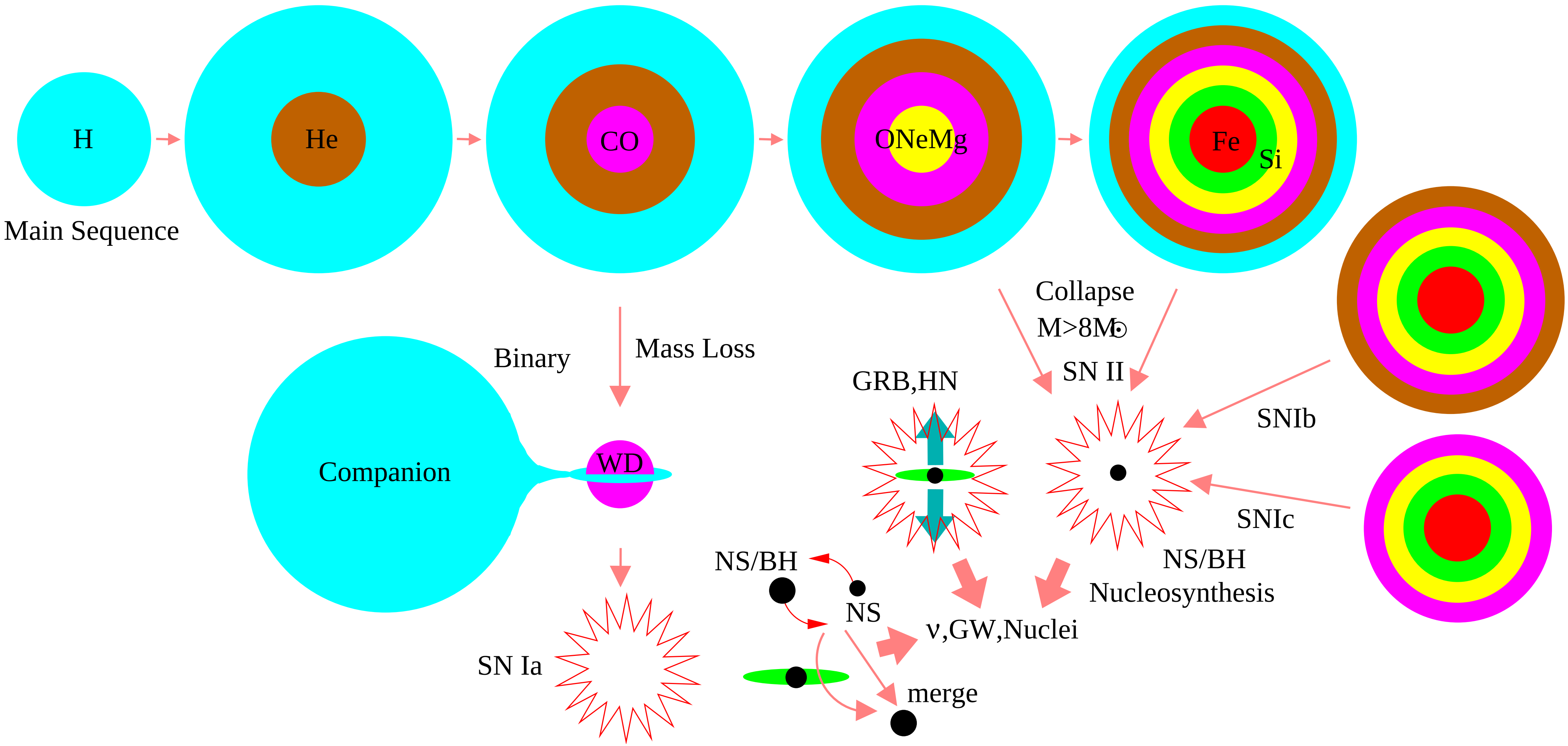

- Nakazato, Sumiyoshi, Ishizuka, Ohnishi, Yamada, Suzuki: Hyperon interaction (EOS) - 1D BH formation
- Izutani, Kikuchi: Systematic study of SN nucleosynthesis (1D models)
- Nakamura: Explosion energy with nuclear reactions




- Kajino: SN,GRB nucleosynthesis with $\nu$ oscillations
- Wanajo, Nomoto: r-process at SN and NS merger




- Kiuchi: Magnetized NS merger
- Kyutoku: GW from BH-NS merger - EOS
- Hotokezaka: GW from NS-NS merger - EOS
- Nagataki: explosiove nucleosynthesis at GRB and HN
- Mizuta; thermal radiation from GRB jets (A04)




- Sotani: EOS - NS normal oscillations
- Nagakura, Sumiyoshi, Yamada: multi-D $\nu$ transfer (collaboration with A04)
- Hanawa: A numerical method to solve transfer equations using moments

# Hyperon Matter and Black Hole Formation in Failed Supernovae

(Nakazato *et al.*, 2011)

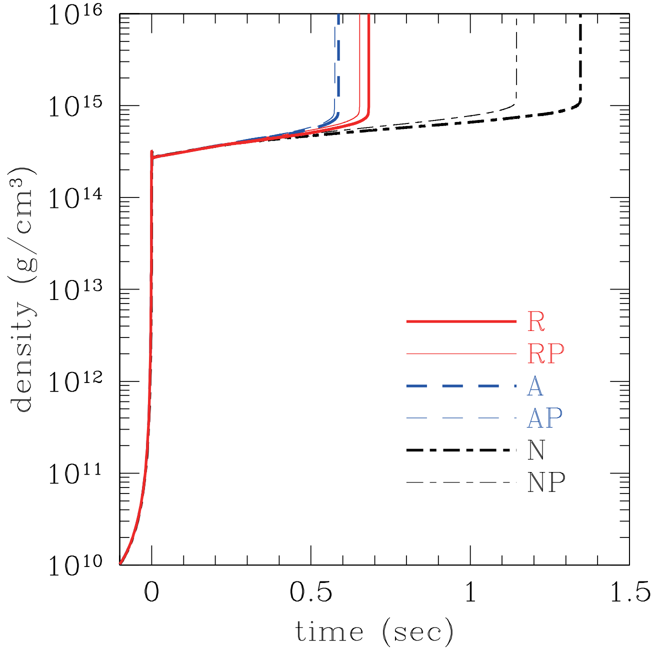



Fig. 2.— Time profiles of the central baryon mass density. Thick solid, thin solid, thick dashed, thin dashed, thick dot-dashed and thin dot-dashed lines correspond to the results for EOS's R, RP, A, AP, N and NP, respectively.

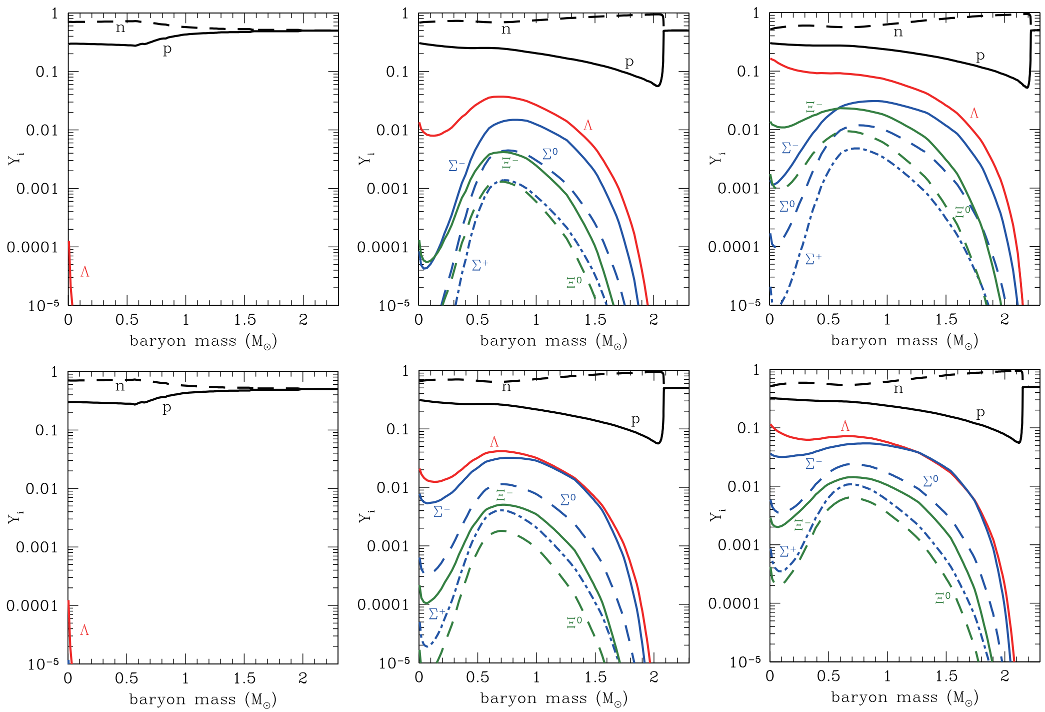



Fig. 4.— Profiles of the particle fractions at bounce (left), 500 msec after bounce (center) and 2 msec before black hole formation (right). The upper and lower panels show results for EOS's R and A, respectively.

Ishizuka EOS = Shen EOS + hyperons

Upper: EOS R $U_\Sigma = +30\text{MeV}$,

Lower: EOS A $U_\Sigma = -30\text{MeV}$

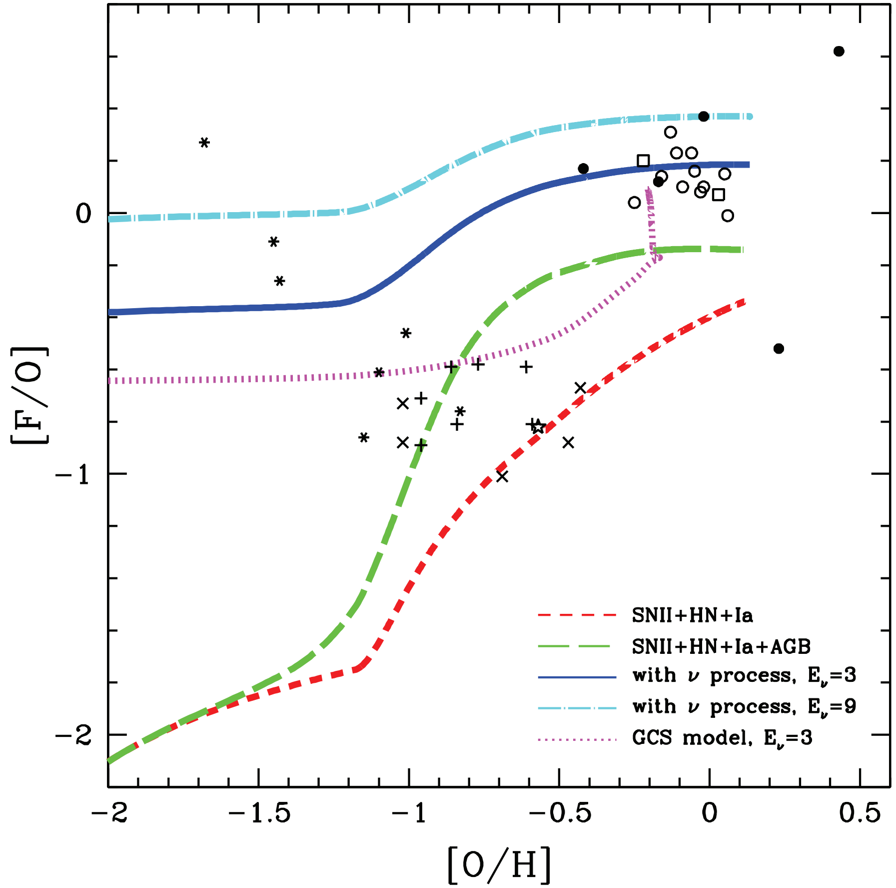


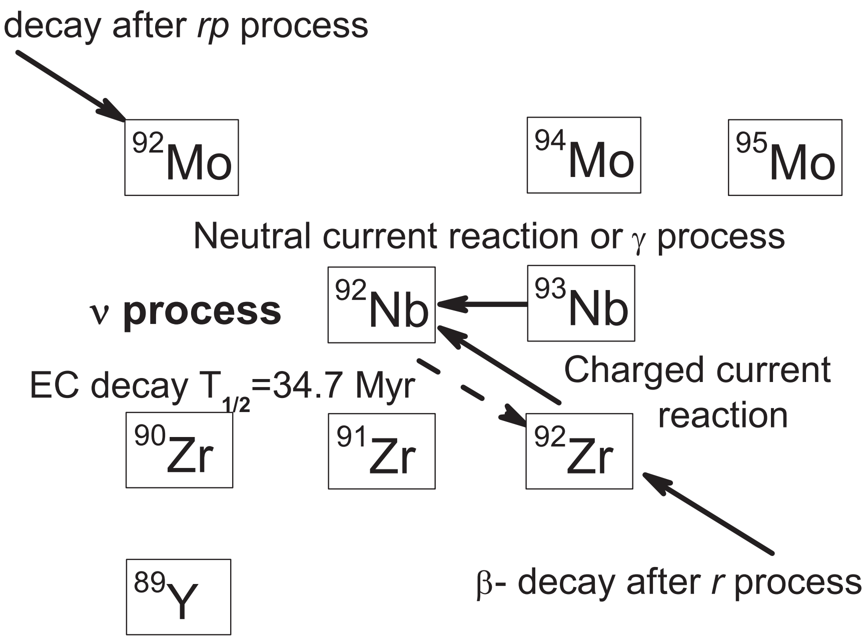

FIG. 1.— Evolution of the [F/O] ratio against [O/H] for the solar neighbourhood with SNe II, HNe, and SNe Ia only (short-dashed lines), with AGB stars (long-dashed lines), with the $\nu$-process of SNe II and HNe (solid line and dot-dashed line for $E_\nu = 3 \times 10^{53}$ and $9 \times 10^{53}$ erg, respectively). The dotted line is for the model for globular clusters. The observational data sources are: open circles, Cunha et al. (2003), open squares, Cunha & Smith (2005) for the solar neighbourhood stars; filled circles, Cunha et al. (2008) for bulge stars. For the stars in globular clusters, crosses, Yong et al. (2008), NGC 6712; plus, Smith et al. (2005), M4; stars, Cunha et al. (2003), $\omega$ Cen; asterisks, Alves-Brito et al. (2011, in preparation), M22.

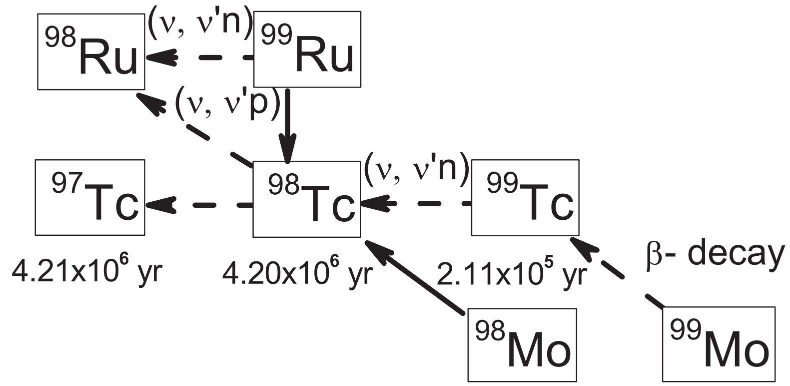
$^{15}$N$(\alpha,\gamma)^{19}$F in convective He shell of AGB

$^{20}$Ne$(\nu,\nu'\mathrm{p})^{19}$F at Type II SNe

# Neutrino induced reactions related to the $\nu$-process nucleosynthesis of $^{92}$Nb and $^{98}$Tc

M-K.Cheoun *et al.*, 2011



# Gravitational Waves and Neutrino Emission from the Merger of Binary Neutron Stars (Sekiguchi *et al.*, 2011 PRL107, 051102)

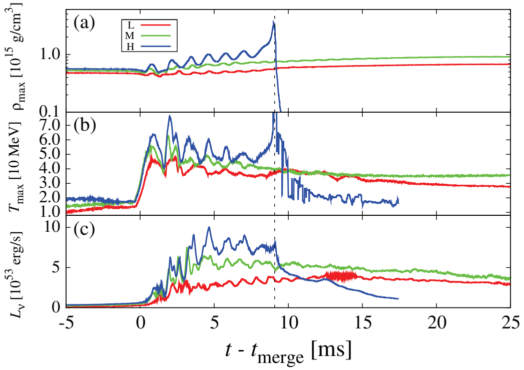



FIG. 1 (color online). (a) Maximum rest-mass density, (b) maximum matter temperature, and (c) total neutrino luminosity as functions of time for three models. The dashed vertical line shows the time at which a BH is formed for model *H*.

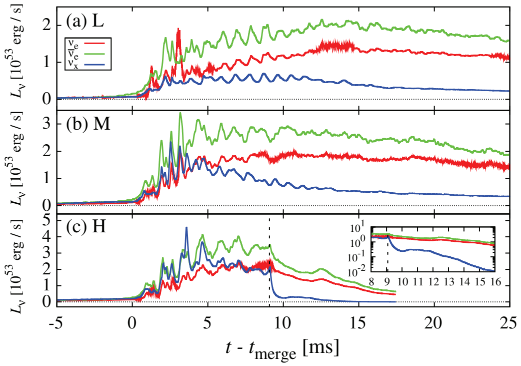



FIG. 3 (color online). Neutrino luminosities for three flavors for three models. (a) *L*, (b) *M*, and (c) *H*. The inset of (c) focuses on the luminosities in the BH formation. The meaning of the dashed line is the same as in Fig. 1.

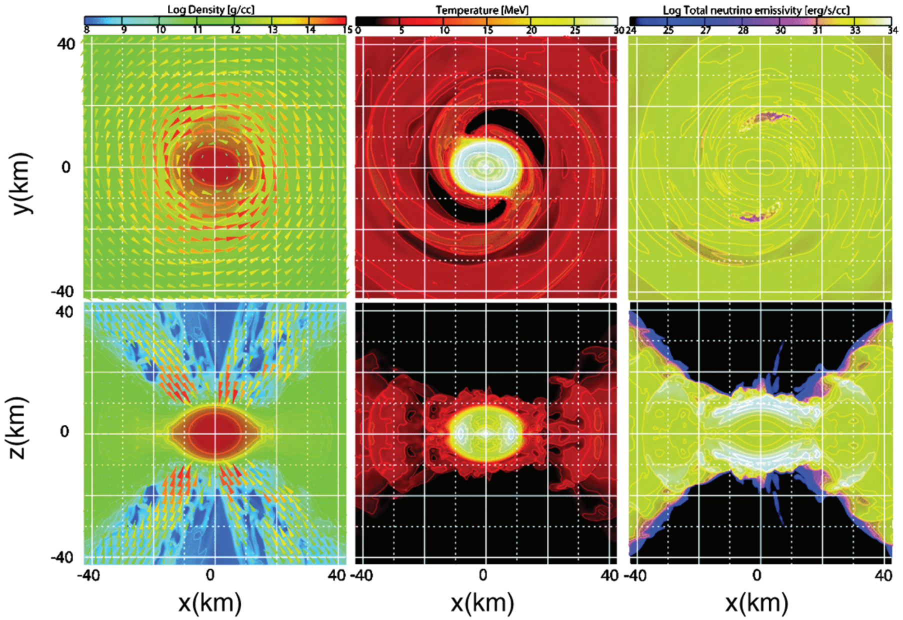



FIG. 2 (color online). Color maps of rest-mass density (with velocity fields), temperature, and total neutrino luminosity at $t \approx 15$ ms after the merger for model *M*. The upper and lower panels show the configuration in the *x*-*y* and *x*-*z* planes, respectively.

L: 1.35-1.35$M_\odot$
M: 1.5-1.5$M_\odot$
Hypermassive NS
$\tau \gg \tau_{\rm dyn}$

H: 1.6-1.6$M_\odot$
(BH in $\tau_{\rm dyn}$)

# Effects of hyperons in binary neutron star mergers (Sekiguchi *et al.*, 2011)

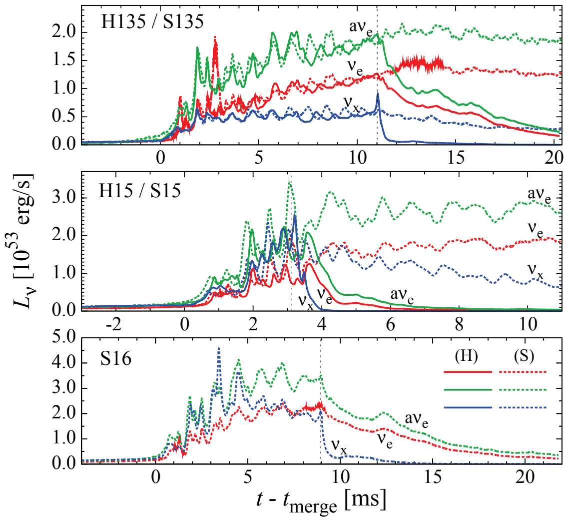



FIG. 3: Neutrino luminosities for H135 and S135 (top), H15 and S15 (middle), and S16 (bottom). The dotted vertical lines show the time at which a BH is formed. The solid and dashed curves correspond to the result with the Hyp-EOS and Shen-EOS, respectively.

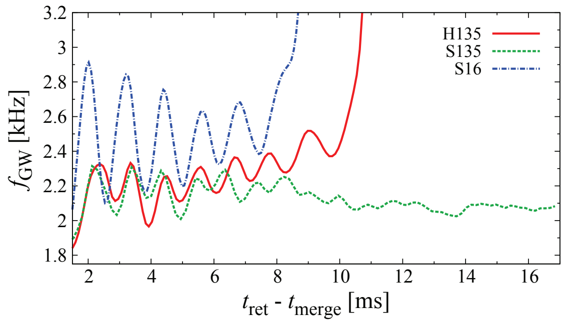



FIG. 5: $f_{\rm GW}(t)$ in the HMNS phase, smoothed by a weighted spline, for H135 (solid red), S135 (dashed green), and S16 (dashed-dotted blue).

H: Shen EOS with Λ
S: Shen EOS without hyperons

135: 1.35-1.35$M_\odot$
15: 1.5-1.5$M_\odot$
16: 1.6-1.6$M_\odot$

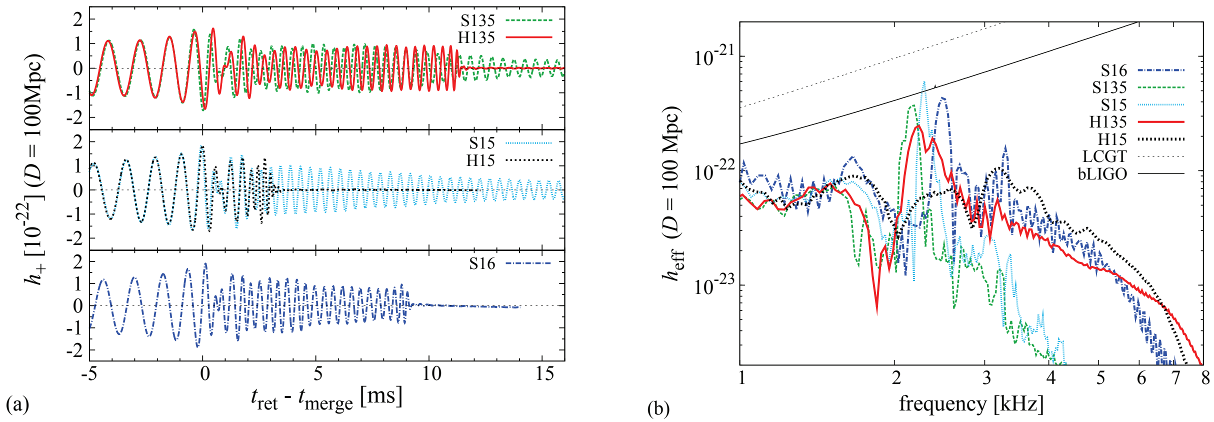



FIG. 4: (a) GWs observed along the axis perpendicular to the orbital plane for the hypothetical distance to the source $D = 100$ Mpc. (b) The effective amplitude of GWs defined by $0.4f|h(f)|$ as a function of frequency for $D = 100$ Mpc. The noise amplitudes of a broadband configuration of Advanced Laser Interferometer Gravitational wave Observatories (bLIGO), and Large-scale Cryogenic Gravitational wave Telescope (LCGT) are shown together.

# Three-dimensional Hydrodynamic Core-Collapse Supernova Simulations for an $11.2 M_\odot$ Star with Spectral Neutrino Transport

Takiwaki *et al.*, 2011

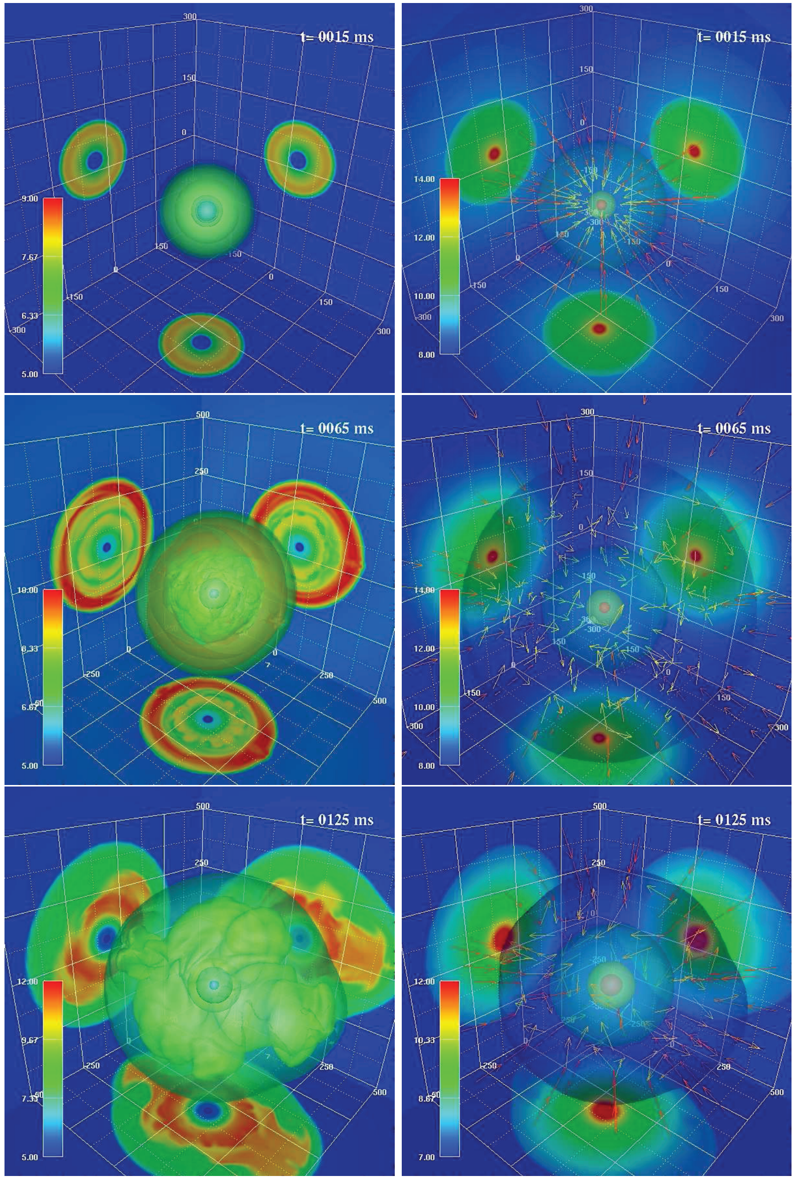



Fig. 1.— Three dimensional plots of entropy per baryon (left panels) and logarithmic density (right panels, in unit of g/cm$^3$) for three snapshots (top; $t = 15$ ms, middle; $t = 65$ ms, and bottom; $t = 125$ ms measured after bounce ($t \equiv 0$)) of our 3D model. In the right panels, velocities are indicated by arrows. The contours on the cross sections in the $x = 0$ (back

## multigroup $\nu$ transfer with IDSA (Isotropic Diffusion Source Approx.)

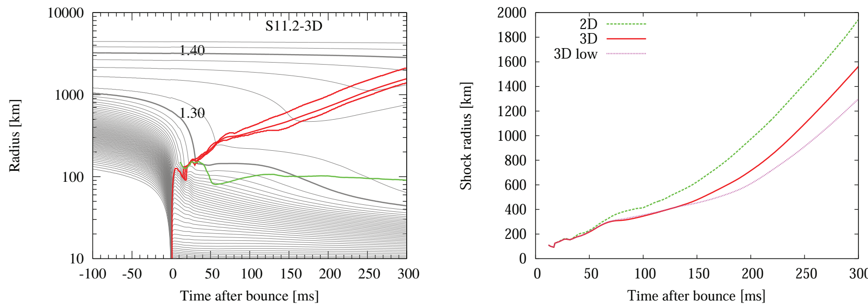



Fig. 7.— Time evolution of the 3D model, visualized by mass shell trajectories in thin gray lines (left panel). Thick red lines show the position of shock waves, noting that the maximum (top), average (middle), and the minimum (bottom) shock position are shown, respectively. The green line represents the shock position of the 1D model. "1.30" and "1.40" indicates the mass in unit of $M_\odot$ enclosed inside the mass-shell. Right panel shows the evolution of average shock radii for the 2D (green line), and 3D (red line) models. The "3D low" (pink line) corresponds to the low resolution 3D model, in which the mesh numbers are taken to be half of the standard model (see Section 2).

# 京都大学基礎物理学研究所研究会「超新星爆発と数値シミュレーション」

2011 年 12 月 26 日 (月)-28 日 (水)

京都大学基礎物理学研究所 湯川記念館パナソニックホール

共催

次世代スーパーコンピューター戦略プログラム：分野５「物質と宇宙の起源と構造」

科研費基盤研究（S）「超新星の爆発機構とガンマ線バースト源エンジンの統一的解明」（代表　佐藤勝彦）

新学術領域研究「素核宇宙融合による計算科学に基づいた重層的物質構造の解明」（領域代表者　青木慎也）共催