# Systematic Features and Progenitor Dependence of Core-collapse Supernovae

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We present our latest results of two-dimensional core-collapse supernova simulations for about 400 progenitors. Our self-consistent supernova models reveal the systematic features of core-collapse supernova properties such as neutrino luminosity and energy spectrum, explosion energy, remnant mass, and yield of radioactive $^{56}$Ni. We find that these explosion characteristics tend to show a monotonic increase as a function of mass accretion rate onto a shock. The accretion rate depends on the structure of the progenitor core and its envelope, which is well described by the compactness parameter.

**KEYWORDS:** Hydrodynamics, Neutrinos, Nucleosynthesis, Supernovae

## 1. Introduction

The explodability of massive stars and their explosion properties depend sensitively on the pre-supernova structures. In this article, we present our neutrino-radiation hydrodynamics simulations in two dimensions using the whole pre-supernova series (101 solar-metallicity models, 247 ultra metal-poor models, and 30 zero-metal models) of Woosley et al. (2002) [1]. We can self-consistently follow a supernova evolution starting from the onset of core-collapse, bounce, neutrino-driven shock-revival, until the revived shock comes out of the iron core. The goal of our 2D models is to study the systematic dependence of the shock revival time, diagnostic explosion energy, mass of remnant object, and nucleosynthetic yields on the progenitors' structure.

## 2. Numerical Scheme

Our 2D models are computed on a spherical polar grid of 384 non-equidistant radial zones from the center up to 5000 km and 128 equidistant angular zones covering $0 \le \theta \le \pi$. To solve spectral transport of electron and anti-electron neutrinos, we employ the isotropic diffusion source approximation (IDSA) with a ray-by-ray approach. We take into account explosive nucleosynthesis and the energy feedback into hydrodynamics by solving a 13 $\alpha$-nuclei network including $^{4}$He, $^{12}$C, $^{16}$O, $^{20}$Ne, $^{24}$Mg, $^{28}$Si, $^{32}$S, $^{36}$Ar, $^{40}$Ca, $^{44}$Ti, $^{48}$Cr, $^{52}$Fe, and $^{56}$Ni. The nuclear energy compensates for energy loss via endothermic decomposition of iron-like NSE nuclei to lighter elements [2]. See Nakamura et al. (2015) for more details [3].