30 years of SN1987A
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Exploding stars with supercomputers and multi-messenger probes of the supernova engine

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A massive star of at least 10 times the mass of our sun ends its life in the most energetic explosion of the modern universe, known as core-collapse supernova. The nearest supernova – and thus also the brightest one – was SN1987A, which occurred in the Large Magellanic cloud (Figure 1) on February 23rd 1987. Moreover, cosmic neutrinos exterior to the solar system were first detected from SN1987A. It was epoch-making not only because it was awarded the Nobel Prize in 2002 but also because it opened up the new files of **neutrino astronomy**, an alternative to conventional astronomy by means of electromagnetic waves.

Furthermore, core-collapse supernovae are at the frontier of yet another novel epoch, the age of **gravitational-wave astronomy**. In 2016, the (potentially Nobel Prize winning) very first detection of gravitational waves was announced by the LIGO collaboration, from binary black hole mergers. The next generation of gravitational wave detectors will be operating in the coming years, which are expected to yield gravitational waves also from core-collapse supernovae – the “mother” of all compact objects like neutron stars and black holes.

Looking back the past three decades of research after SN1987A, significant progress has been made in core-collapse supernova theory. Nevertheless, the fundamental question “**What is the mechanism that drives the explosion of a massive star”?** has not yet been answered satisfactory! In order to unambiguously address this question, one needs to perform large-scale numerical simulations, which involve Boltzmann neutrino transport (generally a 7-dimensional problem) coupled to general relativistic magneto-hydrodynamics. This is the reason why supernova simulations are considered one of the most challenging subjects in modern (computational) astrophysics. Using some of the world-biggest supercomputing facilities, supernova modelers are now reporting on some success (Figure 2), contributing significantly to answering the above fundamental question.

In my talk I will discuss the state-of-the-art of this field and, moreover, illuminate future directions of fundamental supernova research. These relate to **multi-messengers observation:** the simultaneous analysis of neutrino signal, as well as gravitational and electromagnetic waves. It is indispensable that these signatures will reveal the *secrets* of the central supernova engine that is otherwise hidden deep inside a massive star.

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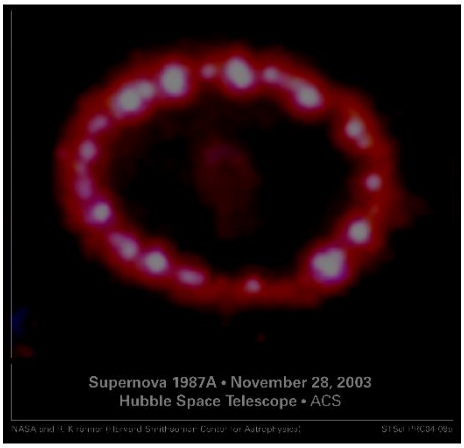

Figure 1

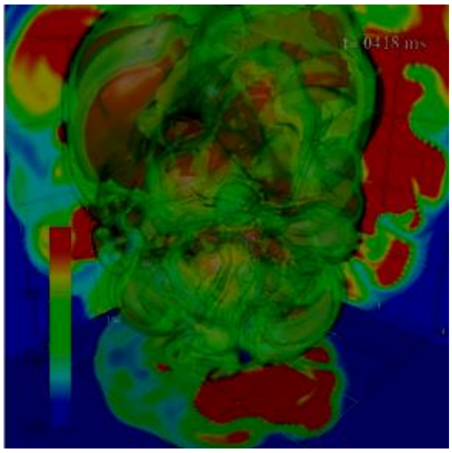

Figure 2