Exploring the possibility of a first order phase transition to quark matter in core collapse supernovae

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Core collapse supernovae are one of the most energetic events in the galaxy. As massive stars reach the final stage of nuclear burning, photodisintegration and electron captures reduce the pressure and the core starts to collapse. Density and temperate increase, nuclei start to dissolve above the neutron drip line and at even higher densities nucleons start to form clusters, which dissolve again as approaching nuclear saturation. At nuclear saturation density, matter is not compressible any further and the collapse halts. The core bounces back and a sound wave forms which quickly turns into a shock front propagating outward. However, this accretion shock stalls due to the energy losses by neutrinos and the dissociation of infalling nuclei. Neutrino reactions have long been investigated to be a possible explosion mechanism, to revive this stalled shock efficiently enough, leading to so called neutrino driven explosions. Although spherically symmetric models, using three-flavor neutrino Boltzmann transport and a sophisticated equation of state for hot and dense nuclear matter, fail to explain such mechanism and multi-dimensional models have become available only recently and reveal the high complexity of such events, the input physics of core collapse supernovae is still subject of debate and can be explored via such spherically symmetric modelling most perfectly. Therefore, as the density increases even above nuclear saturation during the dynamical evolution after core bounce, the possibility of a first order phase transition from normal nuclear matter to quark matter shall be explored. We present results from spherically symmetric core collapse simulations, using three flavor Boltzmann neutrino transport, where the physical conditions after bounce favor a phase transition to strange quark matter. We include an equation of state based on the MIT Bag model with non-zero strange quark mass. The Bag constants are chosen as such to model a phase transition at 2–3 times saturation density for zero temperature.