Collapse models tested at the Gran Sasso underground laboratory

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Abstract. One of the predictions of the Collapse Models, in particular of the Continuous Spontaneous Localization model, is the emission of a spontaneous radiation, which can be tested by high-sensitivity experiments performed in extremely low-background laboratories. We shall present the latest results obtained by running such a dedicated experiment at the Gran Sasso underground laboratory, which allowed to obtain the best limits on the CSL model parameters in a broad parameters space. We also discuss future perspectives and impact of our findings for quantum technologies.

Keywords: collapse models; spontaneous radiation; X-ray spectra; Germanium detectors

Collapse models are phenomenological models introduced to solve the measurement problem of quantum mechanics and explain the quantum-to-classical transition, see [1] for a review. According to these models, the linear and unitary evolution given by the Schrödinger equation is modified by adding a non-linear term and the interaction with a stochastic noise field. These modifications have two important consequences: (i) they lead to the collapse of the wave function of the system in space (localization mechanism) and (ii) the collapse effects get amplified with the mass of the system (amplification mechanism). The combination of these two properties guarantees that macroscopic objects always have well defined positions, explaining why we do not observe quantum behaviour at the macroscopic level. On the other hand, for microscopic systems, the effect of the non-linear interaction with the noise field is very small and their dynamics is dominated by the Schrödinger evolution. Due to the presence of the non-linear interaction with the noise field, collapse models predict slight deviations from the standard quantum mechanics predictions. One of these deviations is represented by the emission of a so-called spontaneous radiation, not present in standard quantum mechanics. In this paper, a new experiment running at the Gran Sasso underground laboratory, Fig. 1, is presented and new upper limits on the parameters of the Continuous Spontaneous Localization (CSL) collapse models are extracted. We obtain the most stringent limits within a relevant range of the CSL model parameters, with respect to any other method [2], [3]. The collapse rate λ and the correlation length rC are mapped, thus allowing the exclusion of a broad range of the parameter space. Future perspectives are also discussed, including: gravity-related collapse models; non-white noise collapse models and impact of our findings in quantum technologies.

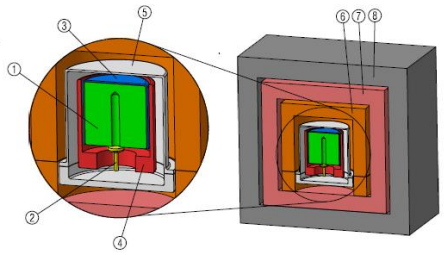

Figure 1: *Schematic representation of the experimental setup: 1 - Ge crystal, 2 - Electric contact, 3 - Plastic insulator, 4 - Copper cup, 5 - Copper end-cup, 6 - Copper block and plate, 7 - Inner Copper shield, 8 - Lead shield.*

References

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