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Linking the International System of Units to Fundamental Constants

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In 2018, it is envisioned that on the occasion of the 26th meeting of the General Conference on Weights and Measures, CGPM, established by the Metre Convention in 1875, will decide to revise the International System of Units (SI). In the future, it shall be based on the fixed numerical values of "defining constants": the velocity of light, the charge of the electron, the Boltzmann, Avogadro and the Planck constants, the Cs hyperfine clock transition and the luminous efficacy. Among them are fundamental constants of nature such that the revision essentially follows a suggestion by Max Planck outlined in his famous paper of 1900 where he postulated the "Planck constant". The revised SI guarantees long-term stability and units that can be realized in any laboratory around the world by suitable experiments. It is anticipated that with technological advances the units will be realized with ever-increasing accuracy, thus triggering innovation in science, industry and technology. As it connects the macroscopic world with the quantum-world it is often also dubbed the "Quantum-SI".

In the talk, an overview will be provided on the progress, challenges and future perspectives of the "Quantum SI", illustrated in Fig. 1, and in particular its role in underpinning what is sometimes called the "second quantum revolution". Moreover, the question is discussed whether the fundamental constants are indeed constant in time. Astrophysical observations indicate changes of the fine-structure constant αover astronomical distances. New experiments are presently being devised, one of them based on next-generation optical clocks using transitions in highly charged ions that are read out via quantum-logic schemes. They bear the chance to trace potential changes in the fine-structure constant α on the level of $\Delta\alpha/\alpha \approx 10^{-20}$ per year.

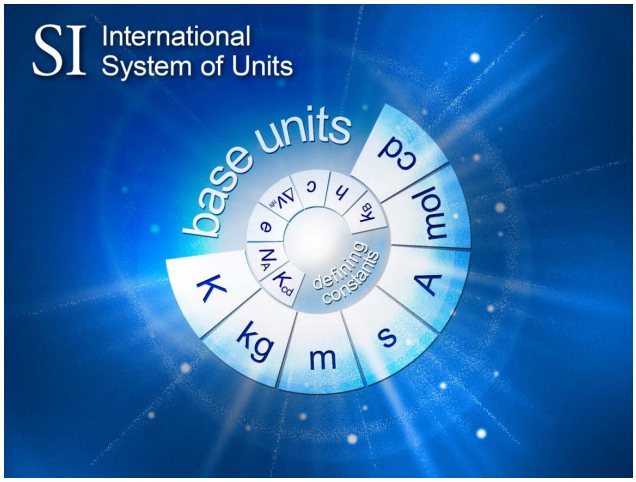

Figure 1. Logo of the New SI with the defining constants and the seven base units.