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A matter wave clock and new measurement of the fine structure constant

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The rest mass of a particle defines its Compton frequency, mc^2/h and thereby sets a fundamental timescale. However, the Compton frequency of a single, non-interacting particle is too high to be harnessed as a clock (about $3x10^{25}$ Hz for a cesium atom) and does not directly give rise to observable effects. Here, we demonstrate a clock that stabilizes a radio-frequency signal to a certain fraction of the Cs Compton frequency, using a Ramsey-Bordé matter-wave interferometer combined with an optical frequency comb. The relative phase accumulated between matter-waves travelling along different paths provides us with an indirect way to access the Compton frequency. The paths are defined by atom-laser interactions, and the frequency comb relates the laser frequency to the clock's own output. In principle, the experiment could still function even if all other standards of measurement were lost. This demonstrates that a single, massive particle indeed defines a timescale, even in practice. This clock relates mass directly to time, which may find application in a new definition of the kilogram with competitive accuracy, by fixing the Planck constant. Moreover, I will report our recent progress on the measurement of the photon recoil frequency using a pair of conjugate Ramsey-Bordé interferometers with large momentum transfer beam splitters. The sensitivity of the interferometers scale quadratically with the momentum transfers on the beam splitters while the common mode noise can be removed by running two interferometers simultaneously. Such a measurement can be used to obtain a new determination of the fine structure constant.