De Broglie's matter waves and the search for new physics

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Abstract

We begin with a historical introduction, to show how in the period 1923--27 Louis de Broglie proposed and developed a new, non-Newtonian approach to dynamics, in which particle velocities are determined by the phase of a guiding 'pilot wave'. Today this dynamics is the basis of what we call the de Broglie-Bohm pilot-wave formulation of quantum mechanics. We then discuss how this dynamics points to the possibility of new physics beyond quantum mechanics, in two distinct ways: (1) initial conditions departing from the Born rule, and (2) a breakdown of the laws of motion at nodes of the wave function (where psi = 0). The first possibility has been extensively investigated in a cosmological setting, and is here summarised only briefly. The second possibility is discussed in more detail, with some possible suggestions for laboratory tests.