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SEMINARIO DE ANÁLISIS MATEMÁTICO Y MATEMÁTICA APLICADA

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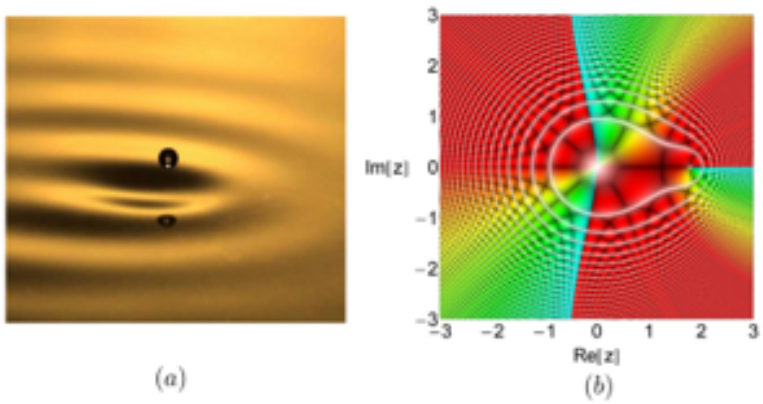
The electrodynamic origin of the wave-particle duality

Abstract. We present a derivation of the wave-particle duality in terms of electrodynamic *self-interactions*. Using the retarded Liénard-Wiechert potentials, and assuming an electromagnetic origin of inertia [1,2], the equation of motion of a nonlinear oscillator for a charged extended electrodynamic body is derived. The stability analysis of the resulting *time-delayed* differential equation (Fig. 1b) reveals that the uniform motion of the body is destabilized through a Hopf bifurcation, producing a self-oscillation [3] with a frequency value that is closely related to the *zitterbewegung* appearing in the Dirac equation [2]. The mechanism triggering the oscillation relies on a feedback interaction between Coulombian and radiative fields among different charged parts of the particle, producing an electromagnetic pilot-wave. Finally, we compute the self-energy of the particle, deriving Einstein's mass-energy relation from Maxwell's electrodynamics, and also obtaining a new contribution that shares fundamental constants with Bohm's *quantum potential* [4].



(a) (b)

Fig. 1: (a) A bouncing silicon droplet on a vibrating bath, showing how De Broglie's pilot-wave dynamics arises in classical hydrodynamics (Image courtesy of Dan Harris and John Bush, MIT). (b) A domain color representation of the characteristic polynomial derived from the equation of motion to study the stability of the uniform motion of an electrodynamic body. An eigenvalue with real part greater than zero is present, destabilizing uniform motion and unleashing a *limit cycle* oscillation.

References

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