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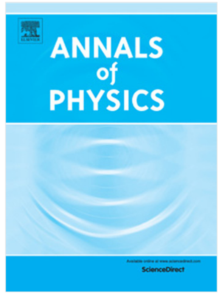


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# Statistical Approach to Tunneling Time in Attosecond Experiments

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**Abstract**

Tunneling, transport of particles through classically forbidden regions, is a pure quantum phenomenon. It governs numerous phenomena ranging from single-molecule electronics to donor-acceptor transition reactions. The main problem is the absence of a universal method to compute tunneling time. This problem has been attacked in various ways in the literature. Here, in the present work, we show that a statistical approach to the problem, motivated by the imaginary nature of time in the forbidden regions, lead to a novel tunneling time formula which is real and subluminal (in contrast to various known time definitions implying superluminal tunneling). In addition to this, we show explicitly that the entropic time formula is in good agreement with the tunneling time measurements in laser-driven He ionization. Moreover, it sets an accurate range for long-range electron transfer reactions. The entropic time formula is general enough to extend to the photon and phonon tunneling phenomena.

*Keywords:* Quantum Tunneling, Tunneling Time, Attosecond Science, Foundations of Quantum Mechanics, Entropy

## 1. Introduction

Tunneling, transport of subatomic particles through the regions of space forbidden to classical motion, is a pure quantum phenomenon. Its physical relevance was first established by Gamow in his analysis of the $\alpha$-decay [1, 2, 3]. The tunnel diode [4, 5] of Esaki was its first technological application. Undoubtedly, scanning tunneling microscope (STM) [6] of Binning and Rohrer started a new pace in scientific and technological advancements. Today, for example, it is known that electron transfer reactions involve tunneling as the underlying mechanism. It governs acceptor-donor transition processes so that charge separation

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