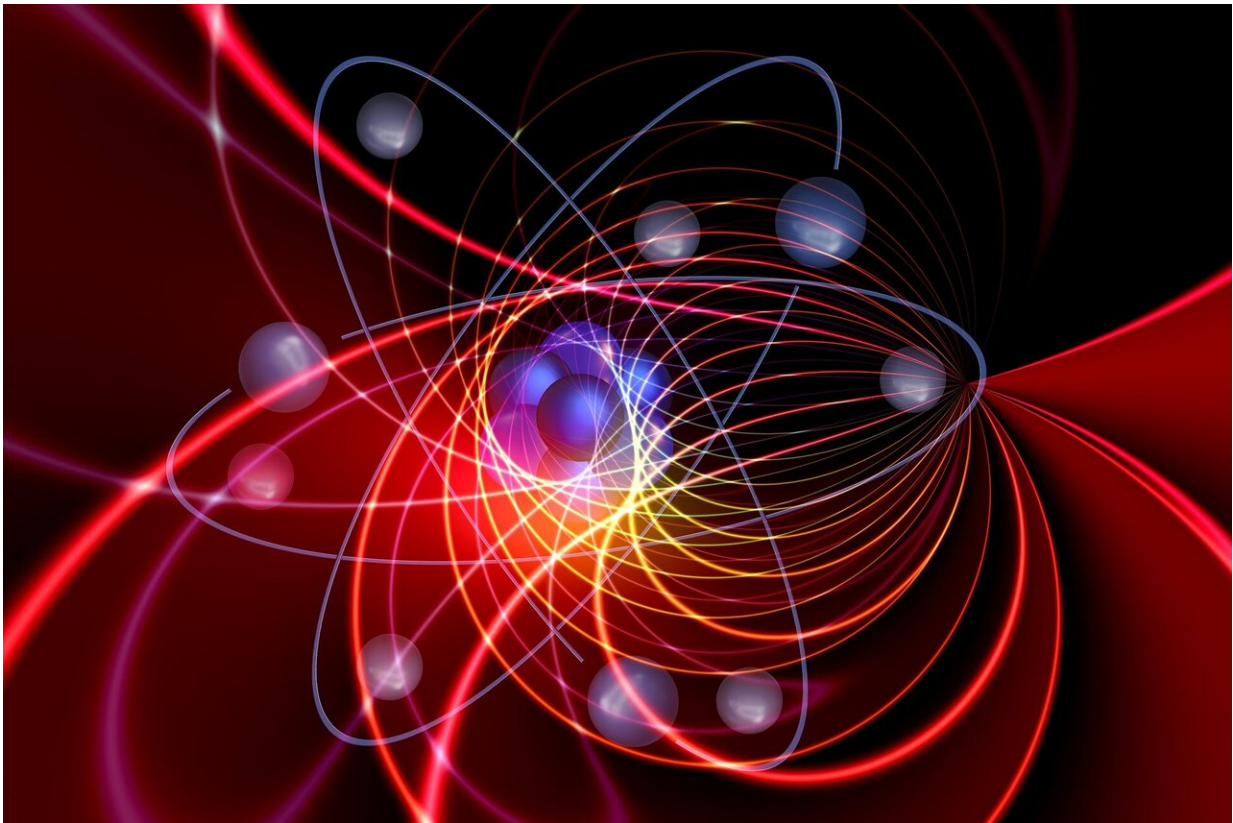


Researchers develop a new quantum-mechanical model

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Quantum mechanics is an extraordinarily successful way of understanding the physical world at extremely small scales. Through it, a handful of rules can be used to explain the majority of experimentally

observable phenomena. Occasionally, however, we come across a problem in classical mechanics that poses particular difficulties for translation into the quantum world.

A new study published in *The European Physical Journal D* has provided some insights into one of them: momentum. The authors, theoretical physicists Fabio Di Pumpo and Matthias Freyberger from Ulm University, Germany, present an elegant mathematical model of [quantum](#) momentum that is accessible through another classical concept: time-of-flight.

Many people will recall the traditional definition of momentum from high-school physics as being the product of the mass of an object and the velocity at which it is travelling. In [quantum theory](#) an object is represented by a [wave function](#) and its position cannot be determined unless the wave function is 'collapsed' into a single state. This is the essence of measurement in [quantum mechanics](#).

Classical momentum can be obtained simply by measuring the time an object takes to pass between two stationary detectors ('time-of-flight'), finding the velocity and multiplying by the mass. Di Pumpo and Freyberger have developed a model of the quantum equivalent of this experiment in which the roles of time and distance are reversed: the time points are fixed, and the probabilistic positions of a wave function at each point, and thus the distance between them, estimated. This approach uses additional quantum systems called pointers that are coupled to a moving wave packet using a method developed by von Neumann, with measurements made to the pointers rather than the wave.

Di Pumpo and Freyberger were thus able to derive a single, measurable quantity that is a quantum equivalent of the classical time-of-flight, and to calculate the momentum of a quantum particle quite precisely on this basis. They end the paper by suggesting ways of further improving the

accuracy of the measurement.

More information: Fabio Di Pumpo et al, Pointer-based model for state reduction in momentum space, *The European Physical Journal D* (2019). [DOI: 10.1140/epjd/e2019-100226-1](https://doi.org/10.1140/epjd/e2019-100226-1)

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