ACTION AT A DISTANCE: GRAVITY

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A NEW PERSPECTIVE BY K. STRANG

Action at a Distance in Quantum Mechanics

The proponents of the Copenhagen interpretation of QM uniformly assert the huge divergence of this theory from Classical mechanics and rely on entanglement or 'spooky action at a distance' to support this view. I shall demonstrate that the differences are not that pronounced and in fact both theories encounter similar problems. Schrödinger is often quoted as identifying entanglement as the dividing line between QM and classical physics:

'I would call it . . . the characteristic trait of quantum mechanics, the one that enforces its entire departure from classical lines of thought.' [Discussions of Probability Relations Between Separated Systems,1935 Mathematical Proceedings of the Cambridge Philosophy Society, pp555-563]

But Schrödinger never subscribed to this view and the context of the above paper and a subsequent paper in 1936 with the same title and journal, are omitted when his conclusion, after very intricate mathematical reasoning was:

'It is suggested that these conclusions, unavoidable within the present theory but repugnant to some physicists including the author, are caused by applying non-relativistic quantum mechanics beyond its legitimate range. An alternative possibility is indicated.'

His alternative involved actual waves and wave phenomena such as resonance. He and Einstein considered QM a useful tool but not the final word on reality. The difference between Newton's theory of gravity and QM is that Newton eschewed any action at a distance even if that was the appearance of the phenomena while the proponents of the Copenhagen interpretation of QM embraced the notion.

Action at a Distance: Gravity

This is initially a problem for Newtonian mechanics which envisages contact and or collisions between bodies to communicate changes in motion. The force of gravity is conjured up to explain the action of planets at huge distances.

The second law of motion, F = ma (force equals mass times acceleration) is measured in Newtons (the SI units are kg x m x s^2) and gravity by the inverse square law where the product of the masses of two object are divided by the square of the distance separating them and measured as kg/m^2 . In order to translate 'gravity' into a 'force' the inverse square law is multiplied by a gravitational constant G which by experiment is valued at 6.67408 x 10^{11} which is the mean of an upper and lower limit with a +/− uncertainty of 0.00031 x 10^{11}. There is no theoretical explanation of this number.

Newton stated in *Principia* that his use of the word 'force' was not to be taken literally but mathematically:

' The words 'attraction', 'impulse' or any propensity to a centre, however I employ indifferently and interchangeably considering these forces not physically but merely mathematically. The reader should hence be aware lest he think that by words of this sort I anywhere define a species or mode of action, or a physical cause or reason.'

Ignoring Newton, gravity has been construed as a 'Force of Nature' but only by virtue of some mathematical jiggery-pokery. No wonder it cannot be reconciled with the other three 'forces' – electromagnetic, strong and weak nuclear forces.

Physicists have taken a mathematical convention and against Newton's express warning turned it into an ontological truth. It is true that the planets move around each other 'as if' there were a 'force' and for all practical purposes the maths works but we should not be led to the belief that a 'force' of gravity actually exists.

A.N. Whitehead (1861-1947) was a great critic of Newton's ontological beliefs:

‘ . . . which presupposes the ultimate fact of an irreducible brute matter, or material, spread through space in a flux of configurations. In itself such a material is senseless, valueless, purposeless. It just does what it does do, following a fixed routine imposed by external relations which do not spring from the nature of its being.’ [*Science and the Modern World* 1926a (Lowell Institute Lectures 1925) CUP and reprinted by The Free Press 1967]

and

‘Newton’s methodology for physics was an overwhelming success. But the forces which he introduced left Nature still without meaning or value. In the essence of a material body—in its mass, motion, and shape—there was no reason for the law of gravitation.’

and

‘There is merely a formula for succession. But there is an absence of understandable causation for that formula for that succession.’ [*Nature and Life*, Chicago University Press 1934; reprinted CUP 2011]

In Whitehead’s eyes, however, the development of Maxwell’s theory of electromagnetism constituted an antidote to Newton’s scientific materialism, for it led him to conceive the whole universe as ‘a field of force —or, in other words, a field of incessant activity’ (ibid, 1934 [2011: 27]). The theory of electromagnetism aided Whitehead in overcoming Newton’s ‘fallacy of simple location’ (ibid 1926a [1967: 49]), that is, the conception of nature as a universe of self-sufficient isolated bits of matter.

The theory of electromagnetism

‘ . . . involves the entire abandonment of the notion that simple location is the primary way in which things are involved in space-time.’

because it reveals that,

‘ . . . in a certain sense, everything is everywhere at all times.’ (1926a [1967: 91]).

and

‘Long ago, Faraday already remarked “that in a sense an electric charge is everywhere”.’

and

‘. . . the modification of the electromagnetic field at every point of space at each instant owing to the past history of each electron is another way of stating the same fact. [*The Concept of Nature* 1920, Cambridge University Press]

Newton is perhaps unfairly portrayed by Whitehead, as in his third letter to Rev. Richard Bentley, Newton explained his philosophical position:

‘It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate upon and affect other matter without mutual contact. That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it.’ [https:// www.newtonproject.ox.ac.uk/ view/texts/normalized/ THEM00258]

When asked for a causal explanation of gravity, Newton replied, ‘I do not feign hypotheses.’

Einstein solved the problem of action at a distance for planets with his GTR which made use of the gravitational constant and interconnected space, time and matter so that matter disfigured space and time which caused curvature and allowed the planets to roll around the sky as they do. Whitehead was critical of this theory too and developed his own theory based on Maxwell’s electromagnetism. An entry in the Stanford Encyclopedia of Philosophy by Ronald Desmet and Andrew David Irvine provides an account of this competing theory.