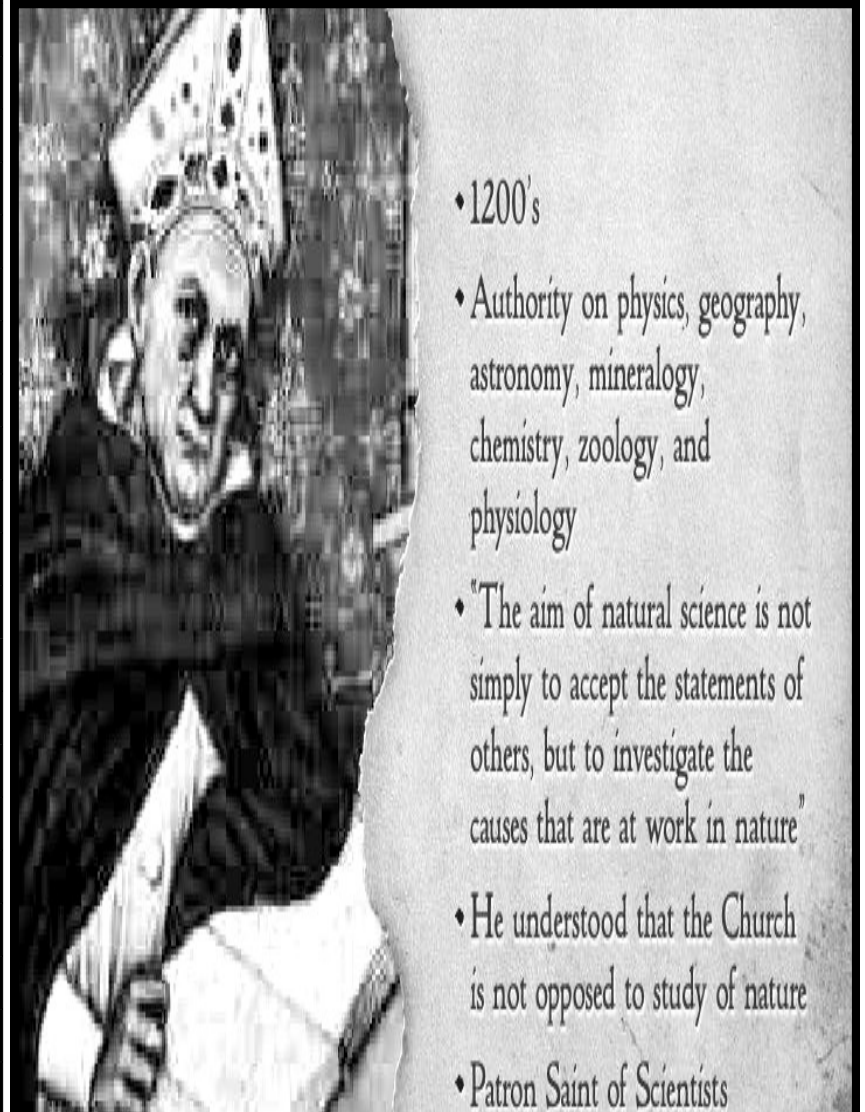




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***Catholic Physics - Reflections of a
Catholic Scientist - Part 41
Free Will and God's Providence: Part IV--
The Many Worlds/Many Minds of
Quantum Mechanics***



- ♦ 1200's
- ♦ Authority on physics, geography, astronomy, mineralogy, chemistry, zoology, and physiology
- ♦ "The aim of natural science is not simply to accept the statements of others, but to investigate the causes that are at work in nature"
- ♦ He understood that the Church is not opposed to study of nature
- ♦ Patron Saint of Scientists

Free Will and God's Providence: Part IV-- The Many Worlds/Many Minds of Quantum Mechanics

"Do not keep saying to yourself, if you can possibly avoid it, 'But how can it be like that?' [referring to quantum mechanics] because you will get 'down the drain', into a blind alley from which nobody has escaped. Nobody knows how it can be like that." Richard Feynmann

"If we look at the way the universe behaves, quantum mechanics gives us fundamental, unavoidable indeterminacy, so that alternative histories of the universe can be assigned probability." Murray Gell-Mann

Quantum Leap Theme / Intro / Opening - JUST THE INTRO @

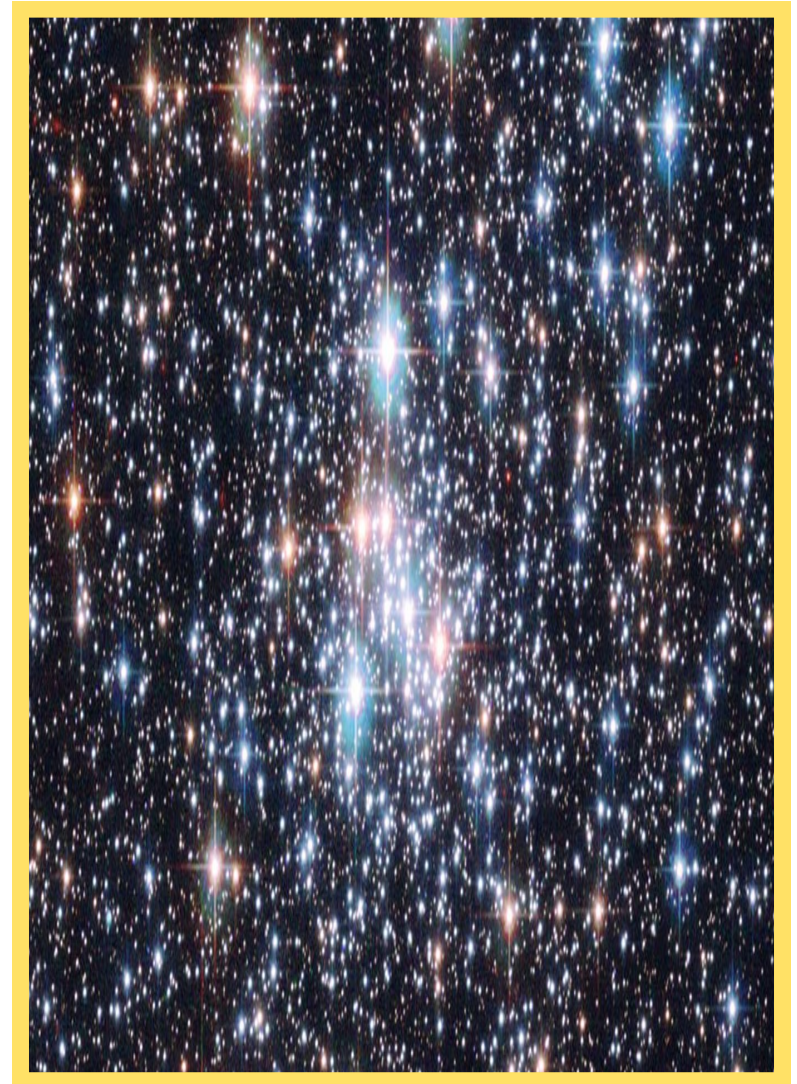
https://www.youtube.com/watch?time_continue=1&v=DjK9GJMBpt0

The video above (from YouTube) is from the introduction to the TV show Quantum Leap , which had the hero jump from one possible world to another, saving people in dire situations and altering history.

INTRODUCTION

In the third post of this series on Free Will my final comment was "It seem to me that if God knows what we will do--even if he does not determine that we do it--we are not totally free in our moral hoices. There need to be options, different possibilities for what we can do, in order that freedom of choice--free will--be exercised... In the fourth post of this series I'll explore what quantum theory might offer to give this freedom."

That part of quantum theory that intersects with Molinism (God's Middle Knowledge) is Everett's Relative State Theory, more commonly known at the quantum Many Worlds Interpretation (MWI) or Many Minds Interpretation (MMI). I'll give a bare bones summary of the relevant quantum mechanics (and references) and then try to show how the MWI can be joined to Middle Knowledge to give a frame for



REFERENCES (other than links given in the post)

Quantum Enigma: Physics Encounters Consciousness, Bruce Rosenblum and Fred Kuttner--a clear, non-mathematical introduction to quantum physics with an emphasis on the many mysteries.

The Quantum Mechanics of Minds and Worlds, Jeffrey Barrett--a comprehensive review of the various interpretations of Barrett's Relative State Theory, deep philosophically but not mathematically.

The Philosophy, Theology and Science of Molinism, Max Andrews--I have not read this book (it has not been published at the time of writing this post) but it seems that it would be relevant and interesting.

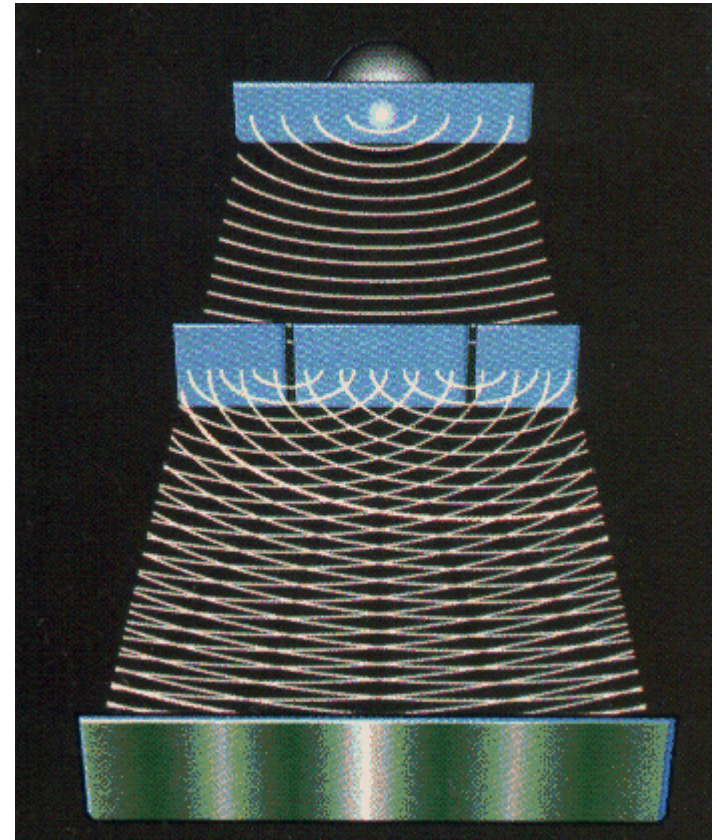
From a series of articles written by: Bob Kurland - a Catholic Scientist



both God's omniscience and man's Free Will. Quantum mechanics references are also given in a previous post. Dear Reader: if all this quantum mechanics jazz makes you queasy (as it does my wife), you can skip to the end of this post to get my take on the connection with Middle Knowledge and Free Will.

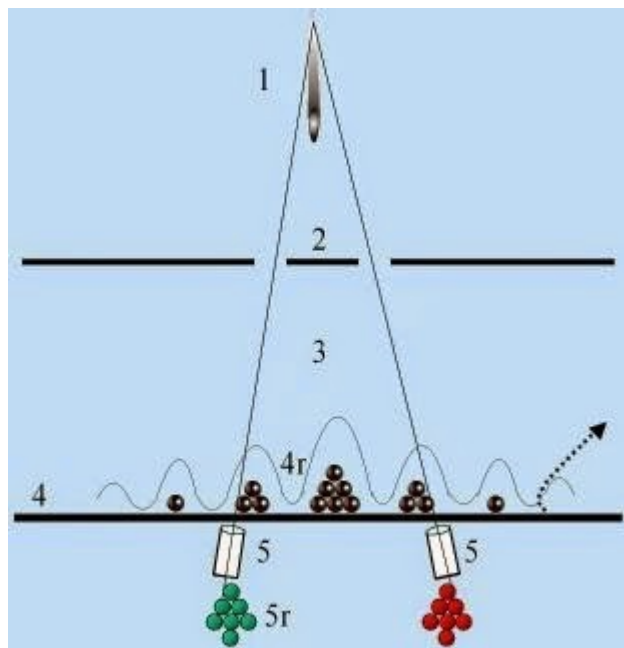
THE SUPERPOSITION PRINCIPLE IN QM AND THE MEASUREMENT PROBLEM.

Superposition in quantum mechanics is best illustrated by the double slit experiment. In classical optics, if you pass a light ray through two narrow slits you'll see an interference pattern as illustrated in the figure below.



The light beam at the top is split and passes through the two slits in the middle. Each of the light rays passing through a slit is a wave, which has positive and negative amplitudes. When a positive part of the wavefront from the left-hand slit meets a positive part from the right-hand slit, they reinforce, to give a bigger wavefront. When a positive part of the wavefront from the left-hand slit meets a negative part from the right-hand slit, they cancel to give a smaller or null wavefront. This phenomenon is interference. The result of the interference is shown on the screen (bottom green band) where the reinforced waves (adding) give intense bands (white) and the canceled waves (subtracting) give dark bands.

One of the puzzling features of quantum mechanics is that particles (electrons, protons, etc.) can behave like waves (as in the light ray above) and waves can behave like particles (e.g. light behave as photons) according to the kind of experiment used to study them.



A common objection to all the above theories is that they are "ontologically extravagant"--they propose too much of reality. But since God is infinite, is that a valid objection? All the interpretations are supposed to fill the following two requirements, among others:

They satisfy the same empirical requirements as standard quantum theory (give the same predictions).

They show how only one of the possible measurements made on a superposed state has been recorded by an observer.

None of the theories, according to Barrett, are totally satisfactory from a philosophical point of view.

Nevertheless, I will suggest below how one or another of the above might mesh with a Molinist point of view to reconcile God's omniscience and man's Free Will.

MESHING MANY WORLDS/MANY MINDS WITH MOLINISM
 Now, finally we come to the point of this post and I will be brief. Let's suppose that a science-fiction perspective for personal worlds exists, a multitude of possible worlds in which there is one where I/my ego/my soul exists. When I make a moral or ethical decision there will be, not a splitting into the two different worlds that would ensue from different decisions, but a possibility for me--my ego, my soul--to go into one or another of those worlds. In this view, God knows of all these possible worlds (the Molinist worlds of God's Middle Knowledge) that might ensue from my moral decisions. Thus God's omniscience and the availability of choices required for truly free, Free Will, are compatible.

result: one in which the particle had gone through the left-hand slit and one in which the particle had gone through the right-hand one. Although this became a standard staple for science-fiction, this interpretation has problems, to name just two:

How are quantum mechanical probabilistic interpretations of measurement applied?

What happens to the identity of the observer--is he in the world with left-hand slit or right-hand?

Other interpretations followed. (I'm not going to do more than list the most important of these with a brief explanation and online references (where available); for fuller descriptions, see Jeffrey Barrett's book, *The Quantum Mechanics of Minds and Worlds*.)

Many Worlds: measurement splits the world into alternatives, one for each component state in the superposition

Many Histories: the linked reference gives Barrett's evaluation of Gell-Mann/Hartle's "Many Histories" approach to Relative State Theory, in which decoherence, interaction of a system with its environment, removes the superposition of component states.

Many Minds: instead of measurement splitting the world, each observer has an infinity of minds, whose distribution is probabilistic and evolves with time, but which are not superposed--a measurement is registered in one of these minds. This approach has been advocated by Albert and Loewer, Lockwood and others.

In addition to the interpretations above, Barrett describes the Bell's (of Bell's Theorem) Everett(?) (sic) Theory, Relative Facts Theory and Many Threads Theory in his book.

Thus, in the figure below, we see particles showing interference patterns, as if they were waves. (If the screen is removed and collimating tubes added as at the bottom of the figure--even after the particles pass through the two slits, as in the delayed choice experiment)--then there is particle-like behavior; red and green particles behave as if they passed through the slit without interference effects--no wave-like behavior.

This behavior is represented in quantum mechanics as a superposition of states. We use the notation " $|\text{state}\rangle$ " to indicate a system is in a given state, or for our example of the double slit experiment:

$$|\text{state}\rangle = |\text{left slit}\rangle + |\text{right slit}\rangle$$

which is to say that a particle going through the slits is going through BOTH the left and the right slits--it is a superposition, as would be the light wave. Now if we put a measuring device near the screen with two slits to detect which slit the particle might have gone through (or use the detecting screen removal and collimators), then we get in the common interpretation of QM,

$$|\text{state}\rangle = |\text{left slit}\rangle + |\text{right slit}\rangle \text{ --(measurement)--} \rightarrow |\text{state}\rangle = |\text{left slit}\rangle \text{ or}$$

$$|\text{state}\rangle = |\text{right slit}\rangle,$$

That is to say, the measurement process has "collapsed" the state function from a superposition to either a particle having gone either through the left slit or through the right slit, but not both simultaneously. (Note: what I have termed "state function" is often termed "wave function", although in many instances there is no wave-like behavior associated with it.)

CONSCIOUSNESS AS A MECHANISM FOR COLLAPSE

Measurement interaction with the particle before it reached the screen (in a superposed state) has effected the collapse, but the mechanism by which this collapse occurs is mysterious, It is represented by so-called projection operators, but these are not implied by or contained in the fundamental equation of quantum mechanics, the Schrodinger equation. So the collapse of a superposed state by the appropriate measurement poses a problem of interpretation.

In the early days of quantum mechanics two great theorists, John von Neumann and Ernst Wigner, gave the following interpretation: since an observer is required for a measurement, and since the final stage of an observed measurement is the belief in the observer's mind of the result of the measurement, one might conclude that consciousness is the means by which the collapse is effected. This interpretation has been taken up with enthusiasm by followers of Eastern mysticism who do not understand quantum mechanics (see What the Bleep for an egregious example) and by some physicists and philosophers, although it is rejected by many physicists for the reasons given below.

If consciousness is the mechanism for collapse of a superposed state, how does one explain what happens if no conscious observer is present? For example, who would the observer be for the universe as a whole? (One answer might be God--see Quantum Divine Action via God, the Berkeleyan Observer, but that would clearly not satisfy many physicists.) What happened in the early universe when there were no conscious observers? The famed American physicist John Wheeler would answer in his Participatory Universe that the past is created by our observation of it.

A more important objection was raised by Hugh Everett: if you consider nested observers, for example, conscious A observes state $|S\rangle$; conscious B observes (conscious A observing state $|S\rangle$), you can deduce contradictions if you try to employ consciousness inducing collapse. Such contradictions led Everett to his revolutionary Relative State Theory (see below).

EVERETT'S RELATIVE STATE THEORY:A STATE FUNCTION FOR THE UNIVERSE.

In 1957 Hugh Everett, then a grad student at Princeton under John Wheeler, produced as his Ph.D. thesis a revolutionary interpretation of quantum mechanics he called "Relative State Theory" and in a later publication (1973) "A Theory of the Universal Wave Function". As Jeffrey Barrett puts it:

"[Everett] wants to drop collapse dynamics from the standard von Neumann-Dirac formulation of quantum mechanics, then deduce the empirical predictions of the standard theory as subjective appearances of observers who are themselves treated within pure wave mechanics as perfectly ordinary physical systems. The problem, however, is that is unclear precisely how Everett intended to account for the determinate records and experiences of observers." J.A. Barrett, The Quantum Mechanics of Minds and Worlds

Everett's idea was to partition the wave-function (state-function) for the Universe into parts for observers and a part (the relative state) for the rest. A given measurement result would be recorded by a given observer, another result for the same physical quantity by another observer. The explanatory gap as to how exactly this would be done (pointed out in the above quote) has led to many theories building on Everett's, theories of "Many Worlds/Many Minds".

MANY WORLDS/MANY MINDS THEORIES OF QUANTUM MECHANICS

In 1970 Bryce DeWitt gave the first of many interpretations of Relative State Theory, a "Many Worlds", in his Physics Today article. DeWitt proposed that at each measurement all possible results occurred, such that worlds split. Thus with the double slit experiment described above, two worlds would