

In simple terms, what does the Stern-Gerlach experiment imply about the nature of quantum systems and observable phenomena?

<http://www.quora.com/In-simple-terms-what-does-the-Stern-Gerlach-experiment-imply-about-the-nature-of-quantum-systems-and-observable-phenomena/answer/John-Ringland>

<http://anandavala.info/article/In-simple-terms-what-does-the-Stern-Gerlach-experiment-imply.pdf>

Google "stern-gerlach experiment" <http://www.google.com/search?q=stern-gerlach+experiment>

My Answer

Quantum mechanics in general and the Stern-Gerlach experiment in particular challenge naive realism ([What is naive realism?](#)) and related aspects of realism but at the same time support other aspects of realism. I'll clarify this...

Firstly the term 'realism' has many different meanings in different contexts, ranging from everyday speech, art and philosophy. It is only certain philosophical meanings that are being challenged.

"The nature and plausibility of realism is one of the most hotly debated issues in contemporary metaphysics, perhaps even the most hotly debated issue in contemporary philosophy. The question of the nature and plausibility of realism arises with respect to a large number of subject matters, including ethics, aesthetics, causation, modality, science, mathematics, semantics, and the everyday world of macroscopic material objects and their properties." (<http://plato.stanford.edu/entrie...>)

The aspect being challenged by QM is that of the "everyday world of macroscopic material objects and their properties".

Realism is "in philosophy, the viewpoint which accords to things which are known or perceived an existence or nature which is independent of whether anyone is thinking about or perceiving them." (<http://www.britannica.com/EBchec...>)

The aspect of this that is being challenged is the idea "**that physical objects exist independently of their being perceived.**" (<http://www.answers.com/topic/rea...>)

Within the context of physics this form of realism can be expressed as the idea that "**all measured values have an actual value before they are measured and independent of that measurement**".

The aspect of realism that is challenged by QM is often identified as naive realism, which is a common form of the type of realism identified above, hence it is often said that *quantum mechanics challenges naive realism*.

"Naive realism, also known as direct realism or common sense realism, is a common sense theory of perception... Naive realism claims that the world is pretty much as

common sense would have it. All objects are composed of matter, they occupy space, and have properties such as size, shape, texture, smell, taste and colour. These properties are usually perceived correctly. So, when we look at and touch things we see and feel those things directly, and so perceive them as they really are. Objects continue to obey the laws of physics and retain all their properties whether or not there is anyone present to observe them doing so." (<http://en.wikipedia.org/wiki/Nai...>)

So QM is not challenging the whole of realism, just certain aspects. It actually supports some aspects, for example:

"Scientific realism claims that we can know about objects beyond what we observe with our bare senses, and this knowledge is what allows us to predict phenomena... This challenges the empiricist claim that quantum objects are simply empirical tools to describe observables... We now know that quantum objects behave differently from everyday objects, and we can make an experimentally supported epistemological claim about the quantum world, a very realist claim." (A Critique of the Empiricist Interpretation of Modern Physics (<http://www.frc.ri.cmu.edu/~gholl...>))

Thus the realist claim that material objects are real is challenged by QM, but the realist claim that wavefunctions and quantum information processes represent something that is real is supported by QM.

The Stern-Gerlach experiment (amongst others) clearly disproves naive realism and the related aspects of realism. This experiment shows that the measured values do not inhere in the quantum system but are created (and destroyed) via the act of measurement. [Note: this is discussed in detail, with mathematical derivation and discussion in the relevant sections of the ebook *System Science of Virtual Reality* <http://www.anandavala.info/SystemSimulation.pdf>

To illustrate the results of that experiment in non-technical terms, lets first consider a situation in naive realist terms and then see how quantum systems differ from this.

The original experiment used the polarisation of spin-states of a coherent beam of silver atoms, however here lets consider instead a stack of cards, these cards have a coloured side (red or blue) and a number printed on the other side (either 0 or 1).

From a naive realist perspective each card must be either a red-0, red-1, blue-0 or blue-1 and each card retains these properties whether or not anyone is looking at them.

Now lets repeatedly sort these cards based upon their properties, say we first look only at their colours and sort them into two stacks, one containing only red cards and the other containing only blue cards. Now lets pick one of these stacks, say the stack of red cards.

Now we look only at their numbers and sort them into two stacks, one containing only 0 cards and the other containing only 1 cards. Now lets again pick one of these stacks, say the stack of 1 cards.

If the principles of naive realism apply then this final stack contains only red-1 cards, so we can sort this stack according to colour and 100% of the cards will be red.

However the Stern-Gerlach experiment proves that this is not the case for quantum systems. We find that the final stack contains both red and blue cards in equal measure.

Furthermore, if we were to pick one of these stacks and sort it by number we would find that it contains both 0's and 1's in equal measure.

This phenomenon relates to complementarity (<http://bit.ly/cZJboy>) and the uncertainty principle (<http://bit.ly/95dD1S>). There is simply not enough information within the quantum system to simultaneously define all observables. The possibility that there may be hidden variables was considered but Bell's theorem disproved this (<http://bit.ly/d3pWh8>).

Hence there is an abstract quantum state, which can produce different observables when measured or experienced in different ways. As we gain certainty about one property the complementary property becomes entirely uncertain. Hence it is NOT the case that "all measured values have an actual value before they are measured and independent of that measurement".

These sorts of experiments underlie statements by quantum physicists, such as:

"nature seems to 'make the calculation' and then present us with an observed event" (J. Gribbin, In Search of Schrodinger's Cat, 111.)

"We have no satisfactory reason for ascribing objective existence to physical quantities as distinguished from the numbers obtained when we make the measurements which we correlate with them. There is no real reason for supposing that a particle has at every moment a definite, but unknown, position which may be revealed by a measurement of the right kind... On the contrary, we get into a maze of contradiction as soon as we inject into quantum mechanics such concepts as carried over from the language and philosophy of our ancestors... It would be more exact if we spoke of 'making measurements' of this, that, or the other type instead of saying that we measure this, that, or the other 'physical quantity'." (E. C. Kemble)

" "[W]e have to give up the idea of realism to a far greater extent than most physicists believe today." (Anton Zeilinger)... By realism, he means the idea that objects have specific features and properties - that a ball is red, that a book contains the works of Shakespeare, or that an electron has a particular spin... it may make no sense to think of them as having well defined characteristics." (P. Ball, Physicists bid farewell to reality? : Nature News <http://bit.ly/dgeHYd>)

"Quantum mechanics is increasingly applied to larger and larger objects. Even a one-ton bar proposed to detect gravity waves must be analysed quantum mechanically. In cosmology, a wavefunction for the whole universe is written to study the Big Bang. It gets harder today to nonchalantly accept the realm in which the quantum rules apply as somehow not being physically real... Quantum mechanics forces us to abandon naive realism." (B. Rosenblum and F. Kuttner)

Since it has been proven that measured values do NOT have an actual value before they are measured, this then has implications on the issue of whether physical objects exist independently of their being perceived. We can only perceive them via their properties, hence if the properties have no independent existence, to what extent can it be said that the objects do? See [What is the "problem of the external world"?](#) and [What is matter?](#)

One of the fundamental properties of a physical object is its position in space and its state of motion, however these are complementary, thus it is impossible for a quantum system to have both a well defined position and state of motion at the same time. The more we increase our certainty of one property the more we decrease our certainty of the other property.

It is in this sense that QM proves that naive realism is false. **What does this imply about the nature of quantum systems and observable phenomena?**

It implies that quantum systems are information processes (computation, awareness) and that observable phenomena are the information content (data, qualia).

“The more one examines the waves of quantum mechanics, the less they resemble waves in a medium. In the 1920s, Ernst (sic) Schrodinger set out a formula which could "describe" the wave-like behavior of all quantum units, be they light or objects... For a brief time, physicists sought to visualize these quantum waves as ordinary waves traveling through some kind of a medium (nobody knew what kind) which somehow carried the quantum properties of an object. Then Max Born pointed out something quite astonishing: the simple interference of these quantum waves did not describe the observed behaviors; instead, the waves had to be interfered and the mathematical results of the interference had to be further manipulated (by "squaring" them, i.e., by multiplying the results by themselves) in order to achieve the final probability characteristic of all quantum events. It is a two-step process, the end result of which requires mathematical manipulation. The process can not be duplicated by waves alone, but only by calculations based on numbers which cycled in the manner of waves.” (A Cybernetic Interpretation of Quantum Mechanics, Ross Rhodes, <http://www.bottomlayer.com/botto...>)

Hence this experiment and others like it imply that there is nothing material or physical about the objective universe, it is an information process. It is our subjective experiences that seem physical, however they do not exist “out there” in a physical universe, they occur as the contents of consciousness. It is the habit of naïve realism that leads us to assume that the objects of experience are external material objects. See [What is naive realism?](#)

Also see:

- [What is consciousness?](#)
- [Is the universe a simulation?](#)
- [What is matter?](#)
- [Now that naive realism has been disproven by quantum mechanics, how will this impact our collective paradigm?](#)