Will we ever be able to truly understand Quantum Mechanics?

https://www.quora.com/Quantum-Mechanics/Will-we-ever-be-able-to-truly-understand-Quantum-Mechanics/answer/John-Ringland

http://anandavala.info/article/Will-we-ever-be-able-to-truly-understand-Quantum-Mechanics.pdf

Yes...

Richard Feynman said "*It is safe to say that nobody understands quantum mechanics.*" Physicists understand how to use it as a tool, but what evades our understanding is what it is actually saying about reality.

What it is saying seems so paradoxical it evades comprehension. However "*The paradox is only a conflict between reality and your feeling what reality ought to be.*" (Richard Feynman)

To truly understand it we need to undergo a paradigm shift into a different way of understanding reality, from which quantum mechanics becomes sensible rather than paradoxical.

If you read this full answer (including the links) and remain unconvinced, I challenge you to think of a single paradox arising from quantum mechanics that doesn't resolve into a sensible and necessary feature of reality when considered from the perspective of the paradigm described here.

For an overview of the current paradigm and why it has been unable to provide us with a genuine understanding, see Do we have a collective paradigm? Else, is it fragmented?

If you intend to read on then please read that link first.

It is commonly accepted that "*If you think you understand quantum mechanics, you don't understand quantum mechanics.*" (Richard Feynman).

However that has been due to the limitations of the current paradigm. With a different paradigm an understanding CAN be attained. I will explain how...

Approaches to understanding

There are two approaches to developing an understanding of things in general:

1. Associating experiences of observable appearances with one's memories of previous observable appearances. For example, watching a ball roll down an inclined plane and understanding how it moves based on previous experiences with moving objects.
2. Developing or studying abstract conceptualisations that describe the relations between observable appearances. For example, developing or studying equations of motion and using them to understand the motion of the ball.

Throughout the following discussion I will refer to these as the first and second approach.

There is however an extra dimension to this, those two approaches can be applied within the context of two paradigms - naive realism and scientific realism. I will discuss these in turn.

Naive realist paradigm:

See What is naive realism?

When the first approach is applied within a naive realist paradigm this leads people to believe that an understanding of what is real can only be achieved in terms of appearances, whether direct sensory appearances or the observables that can be known about systems via experimental measurements. In the context of physics this is called classical objectivism, which is one of the core beliefs of the current paradigm.

When the second approach is applied within a naive realist paradigm this leads people to believe that an understanding obtained by abstractions cannot say anything about what is real, but only describe relations between real observables. This results in the instrumentalist approach to quantum mechanics, where physicists develop a deep understanding of the abstract mathematical workings of quantum mechanics, yet they see this as just a calculational tool.

So the affect of naive realism is to lead people to think in terms of real observables (classical objectivism) and unreal abstractions (instrumentalism).

Classical objectivism is entirely satisfactory in the context of classical physics however it becomes untenable in quantum mechanics because the observable appearances are not objective because we can choose which type of appearance we will elicit from the system by choosing how we interact with it.

Furthermore, these observables are not just hidden away until revealed, they are created in the act of observation and hence have no persistent objective existence - numerous experiments prove this, for example the Stern / Gerlach experiment. See In simple terms, what does the Stern-Gerlach experiment imply about the nature of quantum systems and observable phenomena?

> "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... 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, The Fundamental Principles of Quantum Mechanics)

Many presume that this applies only to the microscopic realm however:

> “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 [and in the many worlds interpretation]. 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". And leave it at that.” (B. Rosenblum, Quantum Enigma : Physics Encounters Consciousness)

> " "[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?)

Thus the appearances are unable to objectively define the system in question. However classical objectivism persists in most discussions and applications of quantum mechanics even though the last explicit vestige of it in the core of the theory was the Bohmian interpretation, which used hidden variables to allow a quantum system to simultaneously have a well defined position and momentum. However that was shown to be impossible by Bell's inequality.

Classical objectivism leads to questions such as Is light a wave or a particle? which assumes that it must be definable in terms of its observable forms. There is no satisfactory answer to this on the level in which it is asked because the wave and particle appearances are not objective and do not satisfactorily define the system.

Hence we get answers like "it is both" or we push the two words together and call it a 'wavicle', or we focus on mathematical abstractions that describe how it behaves but we say nothing about what it actually is, dismissing that aspect as "just philosophy" or even meaningless. Thereby avoiding the question.

All of these approaches are attempts to remain within the framework of classical objectivism when dealing with quantum phenomena. Because of this, wave particle duality (and countless other aspects of quantum mechanics) remain a paradoxical mystery to most physicists. This is revealed by numerous statements, here are a few:

> "Everything we call real is made of things that cannot be regarded as real." (Niels Bohr)

> "It is safe to say that nobody understands quantum mechanics." (Richard Feynman)

> "Quantum mechanics makes absolutely no sense." (Roger Penrose)

> "After more than 50 years (now over 80 years) of unquestionable success as a theory, questions about the interpretation of quantum mechanics continue to plague both physicists and philosophers." (Evelyn Fox Keller)

However:

> "The paradox is only a conflict between reality and your feeling what reality ought to be." (Richard Feynman)

Scientific realist paradigm:

Scientific realism in quantum mechanics does not assume that appearances are the measure of reality, hence it avoids classical objectivism. Instead, a scientific realist is willing to accept that knowledge of reality can be gained in more abstract ways, regarding aspects of reality that don't directly correspond to observables. Hence it takes the mathematical abstractions seriously and not just as a useful tool.

> “The [scientific] realist interpretation [of quantum mechanics]... challenges the empiricist claim that quantum objects are simply empirical tools to describe observables. Thus, contrary to what we might at first think, the wave-particle duality of quantum objects provides support for the realists. 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)

> "There is a major 'dangerous' scientific idea in contemporary physics, with a potential impact comparable to Copernicus or Darwin. It is the idea that what the physics of the 20th century says about the world might in fact be true." (C. Rovelli, THE WORLD QUESTION CENTER 2006)

This is also related to rationalism as opposed to empiricism, where quantum mechanics is fundamentally a rationalist science rather than an empiricist science. Hence it originates from mathematical abstraction rather than observation, and only relies on observation for confirmation not for its foundational concepts. For more on this see Can it ever be said that Scientific realism takes off from the springboard of naive realism?

If people use the two approaches mentioned above to understand quantum mechanics in a scientific realist manner this leads them to think in terms of real unobservables and virtual observables. For instance, see Is light a wave or a particle?

The abstractions are no longer just a calculational tool, they are models of unobservable aspects of reality. This is analogous to understanding how a running computer application, which is real although unobservable to the user, generates the appearances on the screen, which are observable yet virtual.

Consider the interface that you are now viewing on your computer screen. We can try to understand it in terms of the observable appearances, the text fields and buttons and so on. However to really understand it we need to consider the program itself, which is operating in an unseen manner to generate those appearances. When dealing with nature itself we cannot just open up a debugger and peer into the code, however that is what quantum mechanics does indirectly. It models the quantum information processes that are operating in an unseen manner to generate the appearances that portray to us a classical universe. The undeniable accuracy of quantum mechanics suggests that its inferences about those information processes are indeed accurate.

In this paradigm we think in terms of unobservable quantum information processes, which are modelled by the mathematics of quantum mechanics. These information processes give rise to virtual appearances which portray to the observer the appearance of a classical universe. Thus the information processes underlie the virtual appearances.

A logical question to ask is: Is the Universe a Simulation?

So whilst naive realism is a significant obstacle to understanding quantum mechanics and leads people to assume that it is paradoxical or nonsensical, it CAN in fact be understood, but only in a scientific realist manner.

This is also the reason why many computer novices have trouble understanding computers, especially elderly people who have lived most of their lives in situations where naive realist thinking is entirely adequate. For example, they want to send a picture to a friend, they see the picture on the screen and think that the image on the screen is item they wish to send, when in fact the item they wish to send is a file on the hard drive, which is an abstract sequence of bytes that has no observable form of its own.

Those with extensive experience working with computer programming, particularly interface design and virtual simulation, have a deeply engrained understanding of how real unobservable processes can generate virtual appearances. Even playing a lot of VR computer games can, with a little awareness of what is happening, help one to develop an understanding of this. These experiences can make it much easier to understand the wave / particle issue, not as a *paradox* involving two real observables, but as a simple case of a real unobservable system with two virtual appearances. This general understanding sheds light on all of the apparent paradoxes in quantum mechanics!

At the risk of triggering cultural prejudices or of generating too much cognitive dissonance for those who are deeply and unconsciously attached to the naive realist paradigm, it is also relevant to mention that there are others who also understand how real unobservable processes can generate virtual appearances. That is, mystics, for more on that, with quotes that clearly express the parallels, see What can be learned from video games that is hard to learn any other way?

It is also useful to ask: The Big Philosophical Questions: Now that naive realism has been disproven by quantum mechanics, how will this impact our collective paradigm?

For further details on relevant aspects it is useful to read the material at some of the links provided. Given the subtlety of the topic and the distorting affect of knowledge based on the current paradigm, it would be a good idea to familiarise yourself with the alternate perspective otherwise this discussion cannot be understood.

If you read and understand all of that, then it will only point you in a direction and give a few tips on how to proceed. It is you who needs to do the work to shift your paradigm. Some people will be ripe for it, but for most, anything that can be easily understood by reading something is just an extension of the current paradigm. To actually shift between paradigms requires a lot more than that.

A good way to proceed would be to take up that challenge mentioned earlier, i.e. bring to mind all of the existing 'paradoxes' in quantum mechanics and then consider how they can be seen as sensible and necessary features of reality when considered from the perspective of the paradigm described here.