Potentials and Fields: Looking beyond formulas and equations

What do we believe exists in the world when we use science to describe it? In physics we are use to dealing with things we can appreciate with most of our five senses, things we can touch, see or even measure. Things like the force that pulls your hair toward a balloon, or the magnet that sticks to your fridge. These are fields considered real because we can measure them and see their effects directly. But then there is something else called potentials which are more abstract and mostly used in equations to help when calculating things. For a long time, scientists thought of potentials as just tools and not actual parts of the physical world. However, when we step into the world of quantum mechanics and the philosophy of science, things get a little trickier.

First, there are some things to understand such as the difference between fields and potentials. In classical physics, fields like electric fields and magnetic fields are seen as real things. If you place a charged object near another one, you can see how it reacts, and that's how we know the field is there. Same with magnetic fields, you can see them affect a compass or metal objects. Because they have visible, measurable effects, fields are widely accepted as part of physical reality. Now, potentials are something different. In electromagnetism, we use two types of potentials: the scalar potential (usually written as φ or V), and the vector potential (written as A). These are used in the equations that give us electric and magnetic fields. They are helpful mathematical tools for solving problems and simplifying complicated formulas. But they were never thought to be real in the same way that fields are mostly because we cannot directly observe or measure them. It was like they were just helping behind-the-scenes.

This idea worked perfectly fine until the Aharonov–Bohm effect was discovered. This discovery is the game changer of everything and the essence of Sega's article. This quantum experiment showed that a particle like an electron could be influenced by the vector potential, even when there was no magnetic field present in the area it was moving through. That is a big deal because it means the potential caused a physical effect, even though the field was zero. Suddenly, this "invisible helper" that was supposed to just make the math easier actually seemed to be doing something real. Now we recall that to be real is to exist and if something has an effect on the world, especially on particles in motion, then it might deserve the same status as other things we already believe are real. So, Sega asks: If something affects the physical world, doesn't that mean it is real?

In my point of view, the greatest mathematicians read numbers and math as if they were symbols in a language. So, I think that potentials should be taken seriously, not just treated as abstract tools. After all, they symbolize things we cannot see, but that does not mean they are not real. If something plays an important role in explaining how nature works, then it probably deserves a place in our picture of reality. That said, I still consider the topic to be somehow tricky. It is hard to wrap your head around something being real if we cannot touch it or detect it directly. But honestly, a lot of things in modern physics are this way, such as atoms, quarks, or dark matter were all invisible for a long time, and we still believed in them because they helped us understand the world better.

To be honest, this reading made me see science in a different approach. I used to believe that science was only about what we can see or measure. But now I realize that science also involves thinking about what kinds of things must exist in order for our best theories to work. It is not just about hard facts, instead it is also about assumptions, beliefs, and sometimes even philosophy. Science is more than just experiments and equations; it is also about deciding what we are willing to consider real, based on how well something helps us describe and predict the world. And maybe that is what makes physics both so confusing and so fascinating at the same time. This is yet another proof that science is not absolute and unchanging but is tentative and could change over time as more new evidence emerges about how the universe works.

Questions for Discussion:

1. Do you think something has to be visible or measurable to be considered real?
2. If potentials can affect particles even where there are no fields, does that mean they are just as real as fields?
3. Should we believe in things that only appear in theories, like potentials, if they help explain real-world effects?
4. How much should philosophy influence the way we interpret scientific theories?