The Crux of The Matter

By Fay Dowker

There is a crisis at the heart of theoretical physics, a crisis that is largely unacknowledged within the community but the roots of which lie so deep that I claim it severely weakens physicists' claims about what we can rely on as scientifically sound knowledge. Take the statement, ‘Everything is made of atoms’. Now, I believe this, I do not want to suggest that it is not true. But the chain of reasoning that leads from our experimental results to that statement is not, at present, a logically sound one. I believe that it can be made sound –it will require new science –but at present, the claim relies on major fudges and a seriously shifty attitude to the philosophy of science.

The crux of the problem, the fudge and the shiftiness lie in the interpretation of quantum mechanics and this is the subject of my collaboration with Matthew Tickle. In early research for the project, Tickle was drawn to the iconography of a famous experiment called the double slit experiment. One reason he has focused on it is that it illustrates the essential strangeness of quantum mechanics. In this experiment, electrons are fired at a metal plate in which there are two closely spaced, parallel holes in the shape of slits.

Electrons that make it through the holes hit a glass screen on the other side and each electron caused a little flash of light, a scintillation, on the screen so we can see where it hit. If we cover one of the slits and let electrons through only the other one, the overall pattern of scintillations on the glass screen is quite uniform across the screen so that if you blur your eyes it would look as if the screen were glowing uniformly all over. If the second slit is uncovered then the pattern of flashes changes and the scintillation positions bunch up into clusters and there are positions on the screen where the electrons do not hit at all. Again, stepping back and blurring the eyes, the pattern is that of a series of parallel light and dark bands: light bands where electrons hit the screen and dark ones where they don't.

Thinking about this for a while, it becomes clear that this is not what one would expect of little bullet-like particles (which is how most of us tend to think of electrons). Because, a point of the screen that an electron can reach when only one slit is open suddenly becomes inaccessible when both slits are open.

This result was one of the reasons that the early workers in quantum mechanics despaired of being able to give a coherent account of what was happening to subatomic particles like electrons in the double slit experiment. Instead they codified their confusion in a set of interpretational rules for quantum mechanics called the Copenhagen Interpretation, which has become the orthodoxy, the standard version of the theory, written up in text books and taught to all physics undergraduates.

According to this Interpretation we must split the world up into two parts, the quantum system and the rest of the world (that for historical reasons is often referred to as the Classical World). In the double slit experiment for example, it is natural to call the electron passing through the apparatus the quantum system and the apparatus itself (metal plate, screen etc.) is the Classical part. The Copenhagen rules say that we cannot speak about the quantum system, about what it is doing or what its properties are. The theory is silent about it. The theory tells us to calculate the possible outcomes of measurements that are made by the classical apparatus on the quantum system and calculate the probabilities of those outcomes. So, again, in the double slit experiment, we can calculate the probabilities that the glass screen will detect the electron at the different positions on the screen (and that calculation will show that there is zero probability that the electron will land in a dark band, for example) so the overall scintillation pattern can be predicted. But we cannot say what the electrons are doing, we can not even say an individual electron passes through one of the slits. We can say nothing about the electron.

To bolster this Interpretation, the early (and present day) proponents fiercely touted an accompanying positivist philosophy. To those, including Einstein, who were unhappy with the apparent loss of objectivity the early Copenhagenists responded that so long as we can predict the results of all measurements and observations that we can make, that would be enough. We need not –indeed we should not –also demand that the theory provide us with explanatory power about things like electrons which we do not directly see. It is an interesting sociological phenomenon that a group of people, particle physicists, who would probably characterise themselves as the most hard-nosed believers in the existence of an objective reality and of science as the study thereof, are simultaneously the scientists most likely to argue positivistically that so long as a theory gives the correct results for our observations, that is quite good enough (and further, that it would be wrong to ask for more).

My own view is that there isa problem with the orthodoxy. Our inability to say 'what's really going on' can be lived with at the level of an electron perhaps, but it is generally believed that everything is made of electrons and other quantum mechanical particles and if that is the case, the Copenhagen rules force us to silence about what is happening over our shoulders when we are not looking. It forces us to silence about anything we do not observe such as the Big Bang or the centre of the sun. Needless to say the same scientists who support the positivistic Copenhagen orthodoxy have no qualms about making statements about the temperature of the centre of the sun or the creation of light nuclei in the early universe as statements of objective truth.

Thus we have a majority physics community which embraces and defends a theory which gives up on the hope of being able to make observer independent scientific deductions and predictions but which nevertheless sets physics up as the most fundamental of sciences I believe the solution of the problem of quantum mechanics lies in the future, in new science yet to be done. My objective in seeking to collaborate with Tickle has ultimately been to influence this science, to hasten progress. How this may happen is not clear and this uncertainty is inherent in such new ways of working. Possibilities can be seen, however. Already, at a very local personal level, my work with Tickle has encouraged me to devote more research time to working on alternatives to the quantum orthodoxy. At a more general level, I am committed to trying to communicate with the interested public about my research, but not at the level of 'scientists speak and public learns', not in order that people criticise science less, but rather so that they know that sometimes scientists can be their own most powerful critics. The collaboration has given Tickle and myself tremendous opportunities to discuss our respective and mutual interests with diverse audiences.

But the scientific problem is huge and it will require a community of workers effectively to tackle it. There is a small core of committed physicists at the moment, but I want it to grow and it is entirely possible that the artwork that Tickle has created from our collaboration will 'reach the parts other attempts to communicate cannot reach'. The artwork Matthew created from our quantum mechanical conversations goes straight through the eye to the heart of the matter: do we know what is really there?