Why does matter behave like particles when observed, and like waves when not?

The state of a particle is always described by a wave no matter whether its position has been accurately observed or not. If the wave is bunched up tightly around a small region of space then its position is particle-like. But waves can also be spread out over space and the position is no longer like a classical particle's position.

When you measure a particle's position you must use some apparatus. I use the word apparatus very generally, it could mean your eye, say. When you use apparatus designed to measure the position of particle it forces the wave into a tightly bunched shape. The particle doesn’t "know" you are measuring its position. The nature of the apparatus is what causes the bunching. For the apparatus to work, it must interact with the wave and it is the character of this interaction that determines the shape the wave is forced into.

If you were interested in measuring the particle momentum you'd use different apparatus and that would force the particle's wave into a sinusoidal shape rather than a bunched shape.

There are some thorny technical issues over what exactly causes the bunching I mentioned. It's a complex subject because a piece of measuring apparatus is typically macroscopic in size (otherwise we couldn't see it) and describing macroscopic objects using quantum mechanics can be tricky. (See Measurement problem and Quantum decoherence to get a flavour of the complexity of part of the story.) Nonetheless, even if it's hard to describe the exact process behind the bunching (usually called wavefunction collapse), it's fairly straightforward to mathematically model the result of bunching, and it's one of the first things you learn to do in an undergraduate quantum mechanics course.
I have a different interpretation that is radical but I think makes more sense. First we have to question the existence of subatomic particles as concrete objects. There is no particle. There is inter-molecular sensitivity. Contagious charge characteristics which are experienced directly by matter. This would constitute a sensorimotive aspect of electromagnetism which is private and shared between materials, but not publicly in space. This would coincide with our naive perception of energy as experiences in time rather than substances. Light, heat, sound, scale up as events of increasing magnitude and significance, not as physical residues.

What I suggest is that energy works the same way in the microcosm as it does in the macrocosm. It is a capacity for a body to sense the presence of other bodies and their changes relative to the subject as events. Photons of light or radio waves are not a substance which travels through space as projectiles but instead more like a crowd wave which propagates from node to node from within. What this means is that ‘energy’ is a meaningful, i.e. signifying event for bodies of any size and any nature, but with a different qualitative depth and capacity depending on the nature of the body being illuminated. If it is a living human brain sharing the experience of its eyes, then energy is image, color, and brightness. If it is sharing with skin, it’s warmth. It depends on the scale and frequency of the changes which the source body is undergoing.

It may be the case that as we get further down in scale to the absolute microcosmic limit of our detection technology (which is itself only an antenna made of inorganic matter that has limited capacities to resolve the significance of energy events), matter either objectively becomes less ‘objective’, and/or it becomes more subjective. This effect may be an absolute qualifier of existence itself, or it may be a consequence of perceptual relativity. In the former case, complexity alone defines the ‘hardness’ of materiality, while in the latter phenomena which are more ‘like us’ are apt to ‘seem like’ a fugue of possibilities (as our own self and life seems) and the more distant phenomena are from our native perceptual inertial frame are more apt to seem like they are part of a universe which ‘simply is’ (requires no interpretation).
The paradox of a particle that is wave and of quantum uncertainty and the observer effect can be explained then by understanding that there are no literal energy phenomena passing through space, but more like money passing through bank accounts. Here it's an investment, there it's a paycheck, together they are associated with the activity of an employee, but there are no pieces of workness that are shooting out of the bank and into the employee. That's not how it works. If I'm right, and I think that I am, this could be a huge idea. I just don't know what I'm supposed to do with it as a layman. None of the observations or math of quantum mechanics would change, only the interpretation would be turned inside out. The universe is within material bodies only (consistent with the reality of a primordial singularity), and space and time are a true void.
You have to start by realizing the concept of a wave and a particle are poor analogies. Those are words that we understand because we observe them in the macro level of everyday life.

Particles are not tiny billiard balls. A photon is a self propagating fluctuation of the electrical and magnetic fields, running across space.

The "fabric" of the Universe on the subatomic scale is something else altogether. There we go again.. "Fabric." But we may have to keep that macro analogy for now.

The particle does not "know" it is being looked at. It is more like you are zooming into an image with infinite resolution and infinite complexity. Sort of like a fractal. Your mind or whatever device is measuring the energy of this particle locks in a position. If it had been slightly to the left or right, something different would have happened. And it did happen. But whatever is observing it is charting a path through the space of infinite possibilities.

One thing that may help is to look at the instruments that actually measure this stuff. If you really look at what they are, they are "observers" as well, even if they are non-sentient machines. All of our measuring instruments must translate something we can not experience to something we can. It has to convert something infinite and fractal into something discrete... It trips a switch. Again there is infinite resolution at the point of this event.

Perhaps it might help to think of an anti-particle going through the other slit at the same time as the measured particle.

Except there is no such thing as absolute time...