An Allegory of Quantum Wave Functions

In the book *The Theory of Field Interaction*, under the heading of "What We Can Predict or Compute vs. Reality" on pp. 175-177 of the text, is a generalized discussion of quantum wave functions and how there are far more variables involved than we are prepared to deal with. They are not so much "hidden" variables as they are highly dynamic and rapidly changing variables, with values that would be hard (realistically, virtually impossible) to measure and quantify, let alone for us to compute all of the myriad simultaneous equations in even a miniscule chunk of material. This allegory is meant to be an augmentation to that discussion. In this particular case, we will use a commonly used demonstration (at least – I have seen it implemented several times in different science-based museums and instructional venues) as the basis for a allegory that is intended make the actual function and capabilities of the quantum wave functions, relative to Reality, reasonably clear.

The demonstration goes by several names such as the "bean machine", the "quincunx", or the "Galton board" or "box". I do not have any photos of such a demonstration or display available, and some of them are implemented in a better, more repeatable fashion than some of the others that I've seen, so we will seek first to paint a word picture of what an optimum demonstration is like. The main differences between each of the different available demonstrations depend on the number and arrangement of the pegs, balls, and bins that are used. When there are fewer, the outcome is more variable; however, when there are sufficient, the performance or outcome can become highly consistent.

At the time that this was written, there was a YouTube video available at the following link:

http://www.youtube.com/watch?v=AUSKTk9ENzg

The cited video presentation provides an excellent demonstration of the described process (although the purpose of the narration is focused on their index fund performance). There are also other descriptions, discussions, and diagrams available by searching on the web, using the various names.

The basic concept setup is actually rather simple. Note that this demonstration can be done on a tilted surface as well as vertically. Either way, the principles relevant to this discussion remain the same, and the vertical arrangement is more common and simpler to describe – so we will focus our discussion on a typical vertical setup.

We will describe a system that can be viewed from both sides by using two transparent sheets of plastic spaced a few inches apart. At the center top of the transparent sheets, there is a chute with an opening in the center. Below that chute, there is a series of pegs arranged in a regular pattern. These pegs connect the two transparent sheets, maintaining a fixed distance between them, and provide a regular pattern of obstacles for anything that might be falling down between the two sheets of plastic. These pegs are typically arranged in an alternating pattern where as a ball hits the center of any one peg (going straight down), its probability of falling to either one side or the other of that peg is 50-50. At the bottom of the sheets, there is typically a set of vertical dividers that effectively divide the bottom of the demonstration into a series of vertical bins or channels. Those channels serve to keep whatever is falling down into them from shifting sideways so that

one can visualize the nominal distribution of where the balls are landing after falling through the maze of pegs.

Typically, the demonstration uses a bunch of plastic balls of some sort, although any appropriately sized ball would do. As the balls are dumped into the funnel area that feeds the chute, the balls come out somewhat randomly through the center chute (with significant, though possibly relatively minor, variance in their lateral and vertical motions) and fall down through the pegs and into the vertical slots created by the dividers. In a well-designed demonstration setup, the overall result is very predictable – after sufficient balls have fallen through the pegs, the top profile of the balls stacked in the vertical chutes forms a very close match to a standard bell-curve profile. [Note: this pattern can be so predictable that they will often provide a reference diagram of a standard bell curve on the outside surface for comparison with the heights of the balls in each of the vertical slots.] What this means is that the highest concentration of balls, after falling through all of the pegs, are still concentrated in the center – below the chute. However, as one gets farther from the center, there is a decreasing rate, but there are some few balls that end up well away from the center. This is an excellent probability demonstration – and the result is the very familiar standard distribution bell-curve.

To repeat the demonstration, they simply dump out the balls at the bottom and return them to the funnel area at the top that feeds the chute opening once again.

That is the nature of the demonstration, and it is very effective.

To understand how this relates to the quantum wave function, we will make a very slight modification to our thought experiment demonstration – we will take one ball, and only one ball, and imagine that it is colored in some contrasting color. This is done so that we can specifically identify that particular ball each time that it passes through the system and ends up in one of the vertical channels. If there are, say 30,000 balls (a typical number for a good demonstration), we would generally expect that this one ball could eventually end up in any one of some 30,000 nominal locations as we continuously repeat the experiment. The important point here is that, although the overall distribution of balls is rather consistent each time the test is run, we would not expect to find a consistent location for where in the collection that one ball would end up after each run. If we were just to perform a test run, we would not actually know where it actually ended up until we had inspected the collection of balls and located it by its contrasting color.

Does this mean that the process is indeterminate? No! It only means that we have not taken the effort to calculate specifically what is happening with each ball as they fall down through the system. Let's take a moment to look at what that might require.

There are multiple techniques that can be used to return the balls to the chute. Some use a bucket and chain conveyor system. Others might use pneumatic systems. There are certainly other techniques that could be used (including dumping the balls in by hand). The only thing that is important is that whatever technique is used – it needs to deliver the balls with at least some degree of randomness back to the chute so that those balls will then follow a nominally random set of trajectories out of the chute (if they don't – it could bias, and thus, distort the shape of the resulting profile). Let's look for a minute at what happens with any one of the balls as they are

circulated through the system. Remember, these are macroscopically sized balls – typically in the range of ~1/2 inch in diameter – so they follow the straightforward laws of classical physics.

Regardless of what means may be used to return the balls to the chute – if we were to measure or evaluate the initial trajectory, plus every force, contact, collision, bounce, joggle and et cetera that any particular ball is subjected to, we should be able (in concept at least) to calculate the exact trajectory and velocity of that ball as it comes out of the upper chute. Following through with that initial trajectory information, and considering the exact geometry and material characteristics of the chute, pegs, and vertical channels at the bottom, we should also then be able to calculate exactly every motion of each ball and where any particular ball would finally end up at in the bottom vertical slots at the end of that run.

Now, immediately that picture actually becomes more complicated – because we need to know where all of the previous balls had already landed (since they determine what the profile of the top of the stack in each of the vertical channels would be when the ball we are following finally lands). Also, since there are often multiple balls in the system at any one time, we would also need to know the trajectory and path information for any other balls that might just happen to be passing through (in case any of them might happen to collide with, or create some sort of influence on, the ball of interest). Furthermore, we would also need to know about at least some of the balls that might follow after (since they might cause the position of the ball we are following to shift after it lands in one of the vertical channels). Nonetheless, if we had sufficient information and a powerful enough of a computer, we could – in concept at least – calculate ***exactly*** where that particular ball would end up after it was dumped out the bottom and returned through the system.

We know that we could do that if we had sufficient detailed information since this is a macroscopic system, and we know positively that it is fully deterministic and follows the laws of classical physics exactly. Even though it is conceptually possible, it should also be rather clear that to determine all of the requisite information would be rather difficult, if not downright impractical – especially when we add in all of the peripheral information that must be somehow determined, tracked and calculated to obtain this final result.

Now, let's compare what this first approach would require with our other options for determining the final location of that ball after any particular run.

1) We could measure. All that would be required to accomplish that would be to look and visibly locate our specially colored ball after each run.
2) We could ignore the exact location and use statistics. As this particular type of setup is designed to demonstrate, that would tell us that we would expect to find it somewhere – albeit, virtually anywhere – under the probability curve – but it could not tell us exactly where under that curve it would actually be for any given run.

Now then, we have established all of the critical elements for each option:

1> When we measure – we do not need to pay any attention whatever to the initial trajectory, or any of the bumps, jostles, forces, bounces or et cetera, that the ball is subject to during the cycling process. That is because the system automatically responds to every one of them in a fully predictable and consistent manner every time that we run the system – so we do not need to worry

about those details. We then determine the result by simply “measuring” the final location – by locating the differentially colored ball. Our answer then is exact – with all of those added dynamic parameters automatically included and properly accounted for.

2> If we take the simple-to-calculate statistical approach – we can once again ignore all of the bumps, jostles, forces, bounces or et cetera. However, in the final result, we can only identify the probability density information for where it might finally end up (i.e.: somewhere under the bell curve). That is the trade-off that we make when we use the statistical approach. We do not have to have all of the detailed inputs, and we do not have to make such complicated calculations, but we can at least provide a distribution function for where to find it.

3> If we were to want to predict exactly – we would have to determine a whole lot of miniscule inputs and make a lot of calculations. That is possible to do in concept, but, even with our highly macroscopic system, that would likely be highly impractical if not almost beyond the reach of our current technology for at least some of the systems (because we must be able to account for every interaction, regardless of how miniscule it might be).

The Quantum Corollary

Whenever we make a measurement of quantum effects in any real system – we tend to think of our equipment as solid and absolutely fixed (and stable) in its geometry (even at sub-microscopic dimensions). However, after reading *“The Theory of Field Interaction”*, it should become clear that such is not the case. As a start, there are the customary vibrations of all of the atoms and molecules in the substance of our equipment. In addition, there are also other highly dynamic effects such as the following. 1) Free electrons or “holes” that are constantly moving around. 2) A whole variety of other SL dynamic fields [read the book] and resulting electromagnetic wave fields that are introducing phase sensitivities and such to the interactions with any photon or particle that happens to be passing by within appropriate proximity or actually through the bulk of the material.

All of these highly dynamic and rapidly changing parameters are just like the myriad miniscule inputs that would be needed for the exact calculations in the case 3> version with our macroscopic experiment above. However, we do not currently even have the technology for measuring what many of those highly dynamic, submicroscopic quantum scale variables even are. It is not so much a matter of their being “hidden” per se, as it is a matter of their changing too rapidly for us to determine what they really are. For example, we now have the technology to visualize individual atoms in solid materials using atomic force microscopes and similar equipment – however, they are only capable of looking at one very small part of a surface at a time, and they require a discrete amount of time to collect sufficient information. To obtain what we would need would require instantaneity, area simultaneity, and depth…

1) **Instantaneity** Because what we would need to measure are so highly dynamic and changing so rapidly, we would need to be able to make any associated measurements or determinations *instantaneously*. Our current technology takes time to accumulate the data. Thus, whenever we do use something like an atomic force microscope (or any of the many similar instruments), we do not ever measure the exact instantaneous condition, but only the time-average of a whole bunch of those fleeting perturbations.

2) **Area Simultaneity** Our instruments typically look at only a small area at any one time. Even where we only might be concerned with surface interactions, we would still need to know what those surface perturbations were simultaneously over the entire area that would be involved in whatever interaction we are trying to evaluate. Even if we could make instantaneous measurements, the capability to discern such characteristics over a sufficiently large area simultaneously is simply out of reach for our current technology
3) **Depth** Even if we could determine the exact, instantaneous, simultaneous surface perturbations over some reasonably sized area of the surface, such knowledge would not enable us to know what would be happening even one short moment later. To be able to even determine how the surface perturbations would vary over time, we would need to have the capability to collect sufficiently detailed information on what is happening on the inside of the material (below the surface – throughout the entire volume of the material). For us to be able to characterize fully the needed dynamic parameters, we would need to be able to identify, fully characterize, and carefully track every single one of those highly dynamic influences throughout the *entire extent* of any associated materials. That is because, with their highly dynamic nature, any one of them might prove to be part of an interaction with any of the photons, particles or such that we might be trying to measure.

In short, at a quantum scale – the exact calculations option exemplified by case 3> above is currently not even a remotely viable possibility. Even if we were to get to where we understood all of the respective parameters adequately, and then to build a computer model of an imaginary block of substance with all of the dynamic parameters pre-defined – it would likely require more computing power than we have available to calculate everything that would be required in anything close to real time. It could very possibly require hours, days, or even longer just to make the calculations for a few seconds of real world time.

Thus – for the quantum corollary – the only real approaches that we realistically even have available to us are to make a statistical prediction, and then to make an actual measurement. Remember though that, just as was exemplified by the fully deterministic, macroscopic analogy case using the balls that was described earlier, the statistical approach can only give us a statistical distribution, NOT an exact location! Meanwhile, when we make a measurement, it will typically provide us with an exact location – at least within any other measurement uncertainty limitations. What we are asserting here is that, just as with the macroscopic example above, Reality is fully deterministic and always knows exactly where everything is and in what direction it is going. It then determines there-from exactly where it should go after any sort of interaction – but that those interactions are also subject to some highly dynamic, rapidly changing influences as well. Reality may know exactly what all of those highly dynamic, rapidly changing influences may be – but the key to recognizing what we are actually observing is to realize that WE do NOT!

Some Added Perspective

Before we finish, let's look at another analogy in an effort to make sure that the significance of the above points is clear. All of us have seen situations or at least pictures where whatever is in the background of a scene is reflected beautifully off of some body of water. I would imagine that it would be clear to everyone that for such to happen, the surface of the water must be relatively quiescent. Likewise, as any disturbances that might be on the water are increased, the image

would become progressively disrupted. Whenever the surface of the water is totally covered with waves – no reflected image is discernible.

When the laws of specular reflection are taught – the focus is normally always on the specular part of the reflection – that part of the reflected light that predictably obeys Snell's law (where the light leaves the reflecting surface at the exact same angle from the surface normal as the original incoming light). While it is effectively possible to get perfect specular reflections at some of the longer electromagnetic wavelength frequencies, at very short optical wavelengths, such as those of visible light, there is no such thing as a perfectly specular reflecting surface. While with shiny surfaces, such as polished metals and mirrors, most visible wavelength light is typically reflected specularly, there is always some of the light that is reflected diffusely, meaning that it emerges from the surface at some angle other than the specular angle specified by Snell's law. How much of that light is actually reflected diffusely depends very strongly on the microscopic character of the surface. The intensity of this scattered diffuse light can be characterized and specified for a surface by measurement over whatever solid angle may be appropriate, and is called the Bi-directional Reflection Distribution Function, or "BRDF".

For an ideal diffusely reflecting surface, the BRDF would be uniform in intensity over all directions (or the entire hemisphere) off of the surface. The more perfectly specular that a surface is, the greater the intensity at or near the specular angle specified by Snell's law becomes, and the less intense the light reflecting off in all other directions becomes. While we may be able to approach perfect specularity, as stated before, we do not have the capability to make *any* surfaces where the diffuse light at the non-specular angles for shorter wavelength light waves, such as visible, ultraviolet, and et cetera, is all zero. We propose that there are really two aspects to the causes for this diffuse reflection, and this is where we get back to the focus of this particular discussion. The sources for this diffuse reflection are presumed to be as follows:

1) Microscopic ripples in the surface profile While the surface of a mirror or shiny surface may appear to us to be extremely smooth, at the length scale of the wavelength of visible light, for example, there are always some degree of fixed surface irregularities or rippled surface profiles. There are techniques whereby the extent and height of these ripple profiles can be reduced – float glass, for example, which is solidified on a liquid surface, tends to have a much smoother submicroscopic profile than does the surface of ground glass. This is in distinct contrast to the fact that the float glass can typically have more visibly evident macroscopic irregularities than will a high quality ground and polished glass surface. The main point here is that any fixed-profile ripples that are on the order of the wavelength of the light or larger will contribute to the diffuse reflection since they cause the surface to locally deviate from the nominal plane of the surface (even if only microscopically).
2) Dynamic influences and effects at the material surface This is the type of effect that has been the primary focus of this discussion. While we may be able to reduce the ripple profile of a surface by the careful selection of fabrication techniques, we would likely not be able to with the dynamic effects. It is very possible that there would be some sensitivity to the material composition; however, so long as the nominal material composition is unchanged, the diffuse reflection contributions specifically attributable to dynamic effects at the surface would be expected to remain nominally unchanged regardless of how the surface of the

material is actually fabricated. The relative magnitude of this effect may vary to some degree with the nature of the material, but it would always be expected to be present to some degree.

A possible verifying test Using an appropriate set of profiling equipment, it should (in concept at least) be possible to actually measure the fixed ripple characteristics of a sufficiently large part of a surface to enable the characterization of how much of the diffuse reflection coming off of that surface could be attributed specifically to fixed microscopic ripples. For this test to work properly, it would be critical to characterize the profile at dimensions sufficiently below the wavelength of the light being used to test the BRDF that it would be possible to have full confidence in the accuracy of the resulting characterization. Once that was accomplished, it should then be possible to subtract those results from the measured BRDF of that surface to determine how much of the diffuse reflection ought to be attributed to be a direct result other factors. Especially for a highly reflective polished metal surface, where the penetration of the photons should be essentially zero, any residual diffuse reflection effects observed in the BRDF should be a result of the previously unaccounted for dynamic influences and effects to we have been referring in this discussion.

We may not realistically be able to characterize the dynamic influences within any solid sufficiently, at least from current theory, to make calculations of exactly where a quantum-scale interaction might place the final result for direct comparison with our experimental results. Nonetheless, a series of tests similar to what was just outlined should be able to demonstrate conclusively that this particular set of dynamic effects is real, and possibly even enable us to quantify the overall magnitude of its influence for some range of materials and surfaces. What we would expect that such an effort would be able to show, would be at least a general gauge of how much of the observed quantum “uncertainty” or “indeterminacy” in the observed diffuseness of the reflections are actually a result of previously uncharacterized dynamic effects. While such may not be sufficient to fully characterize the extent of such factors on the indeterminacy of our quantum measurements – it would at least be a start in the right direction.

What we have been trying to show is that the seeming “collapse” that occurs at measurement (from “indeterminate” to “determinate” as it is customarily taught) is not real in Reality – it does not truly reflect what is really happening in nature. It only *seems* that way because WE cannot provide all of the needed inputs to make an exact calculation. That “collapse” then would more properly be understood only to be a reflection of the inherent differences between the relatively nebulous output of the statistical approach and the exact answer provided by measurement.

Summary

In summary – I sincerely believe that (at least, after reviewing the information that has been provided) it should be reasonably clear to any rational person that, in all probability, there MUST be some combination of highly dynamic parameters (at least similar to those mentioned) in ANY chunk of material. Furthermore, when convolved together with the SL dynamic fields, phase sensitivities, and other variances that are also intrinsically associated with any photon or particle – there MUST therefore be critical interaction parameters that we cannot (at least at the present time) either predict or track.

Meanwhile, while we may not be able to measure or track them, we would expect that any quantum scale interactions occurring in Reality – which are highly dynamic and sensitive – would surely be expected to be very responsive to them.

Thus, we maintain that there is no actual, bona fide evidence that truly indicates, even at quantum scales, that Reality is "indeterminate". Certainly, at least, until and unless testing is able to prove that none of the above-cited effects actually exist, any presumed evidence of "indeterminacy" would need to be held in very strong question of its validity. The techniques that we currently do use to predict any quantum outcomes have all of the earmarks of a statistical, probability-based approach. Furthermore, I have never seen any evidence of efforts even to truly identify all of the dynamic variables associated with any of the materials that compose our experimental equipment. Even such basic considerations as atomic vibrations, free electrons, and electromagnetic field phases have long been recognized as being a part of all known materials – yet, they seem to have been ignored in quantum-scale interaction evaluations.

Furthermore, we have also presented an experimental approach that should enable us to characterize, at least roughly, how much of an influence such dynamic effects would have for at least some particular situations. If the results of such tests do, in fact, produce the expected result – then it would provide a starting point for getting closer to the truth of how much of an effect the dynamics in materials are clouding our ability to see what is truly happening in Reality.

Assuming that such were indeed to prove to be the case, the only rational conclusion that could likely then be reached would be that the quantum wave function only provides the probability distribution for where we might be able to find whatever it might be that we might be looking for – not its actual "location". Subsequently, from that – it would seem that whenever we do measure something, it does not represent any sort of "collapse" from indeterminate to determinate in anything more than *our knowledge* of what the actual condition might truly be. To try to support any other position would be to ignore some very salient information that lies right before our eyes, even if, perhaps, it may be less than obvious.

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