Longer Dissertation Abstract

Quantum Ontology

My dissertation discusses the ontology of pairs of particles in quantum mechanics as well as the ontology of loop quantum gravity (LQG). In this abstract, I will describe only the latter project since LQG is less well known and since I discus quantum particles in “Weak Discernibility and Relations Between Quanta.” In order to describe my project concisely, some of what follows is not a perfect representation of either LQG or its attending philosophical issues; in order to provide a manageable and concise representation of the theory I have had to make a few idealizations.

The theory of loop quantum gravity aims to provide a description of gravity in extreme regions: the extraordinarily small “Planck-sized” regions of space-time as well as the extraordinarily exotic regions at the first moments of our universe or those around black holes. These extreme regions are theorized to exhibit phenomena which classical general relativity is unable to explain. Theories like LQG aim to describe the phenomena in these regions by providing a quantum version of general relativity; however, since general relativity is also thought to be a theory of space-time, LQG has been charged with the conceptually daunting task of providing a quantum theory of space-time itself.

By providing a quantum theory of space-time, LQG is interpreted as describing physical structures which are the building blocks of space-time. However, since the physics of LQG is somehow “before” or “beyond” space-time, the theory of LQG must not use notions which rely on space-time for their meaning. Such notions include: causation, particle, field, momentum, locality, force, energy, mass, *etcetera (f*or instance, some standard accounts of causation require that causes come *before* their effects.) Thus, much of the standard furniture of physics is automatically out of bounds for expressing the physics of LQG. It should come as no surprise then that philosophical analysis has and will continue to play a crucial role in helping to mold the theory into a conceptually coherent form. New paradigms for how to think of physical systems and how these systems relate to space-time will need to be developed and applied to the theory of LQG.

With respect to my research, I explore the ontological commitments of LQG and argue that the “received” interpretation wrongly identifies what is ontologically basic to the theory. The received interpretation of LQG posits the existence of network-like objects (a web of loops and lines connected at nodes of intersection) which carry gravitational charge along their loops, links and nodes. According to this interpretation, the more charge a network has, the more volume it produces. The networks of LQG build space-time one region at a time as geometry spills from them.

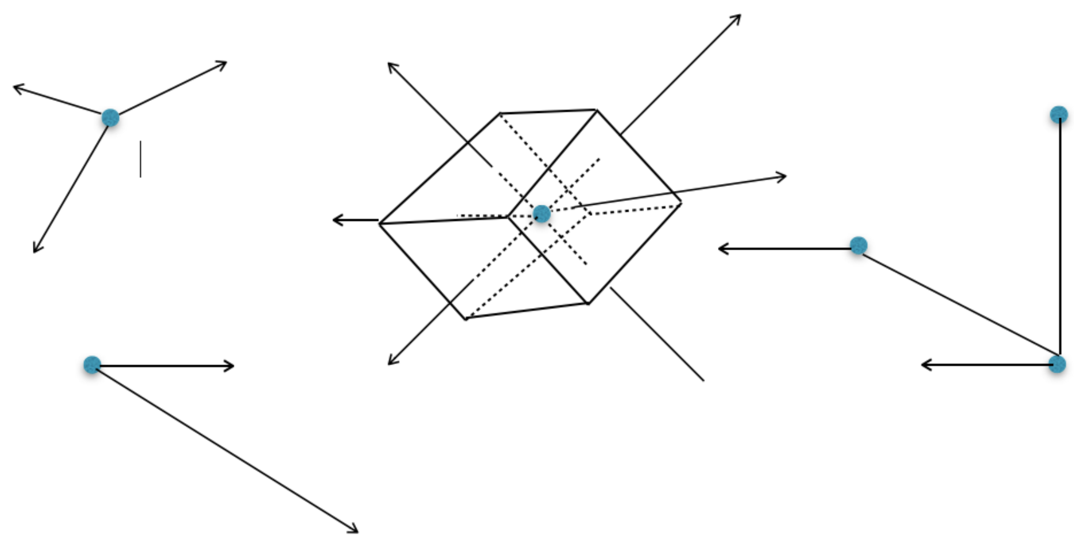

Figure 1: A series of networks: gravitationally charged links and nodes. Each node defines a volume of space and each link, an area.

However, given that the networks are somehow prior to space-time, what or where exactly are they? Are they really like a web even though they have no spatial extension? Are they somehow hidden inside of space-time such that if we looked hard enough, we would find them? Are they really composed of gravitationally charged one dimensional links and point like nodes?

The ontological status of the networks of LQG is a complicated and murky topic. In my dissertation, I argue that in LQG there actually are no web-like networks; rather, the networks are mathematical heuristics which keep track of the properties of space-time at the quantum scale. There is a tendency to take images like Figure 1 too seriously: instead of there being two things in LQG—networks and space-time—there is only space-time or more precisely a quantum version of space-time and no networks. Clarifying this issue is very important to the philosophical foundations of LQG and in particular for understanding its ontology. Just as quantum and Einsteinian mechanics upset our metaphysics of objects and individuals, of energy, time and space, so too the theory of LQG will alter some of our basic metaphysical assumptions and yet, before we can be confident how it might do so (and there are proposals), we must first understand what the ontology of LQG is and what it is not.

In the course of arguing that the networks of LQG ought not be reified, I show that what LQG is committed to is far more strange than simply networks which carry gravitational charge. I argue that the quantum states of space-time, which are responsible for the geometry of the world, are themselves neither in space-time nor are casual. Thus, under two standard accounts of what it means to be an abstract object, LQG is committed to there being physical objects which are abstract. As one might expect, the analysis which leads to this conclusion is not airtight; yet, given that the analysis has a surprising amount of resilience, I suggest that the abstract-concrete distinction be reevaluated under the paradigm suggested by LQG.

Notions like *causation* and *abstract* are often tied, in one way or another, to our classical folk theory of space-time. As such, there may come a day when modern physics has so dramatically re-described space-time that space-time is unable to play the conceptual role(s) we had hoped it to. Thus, even if LQG is false, it provides both a motivation for and a non-spatial paradigm against which to test our conceptual commitments.