# 7.9: Wrap-up

We have now developed models to enable us to use the three fundamental conservation laws of all of science: energy, momentum and angular momentum. The "before and after the interaction" approach, which now includes momentum and angular momentum, as well as energy, is extremely general and universally applicable. It allows us to get answers to most questions we ask regarding the behavior of interacting systems, as long as we don't need the time dependence of the dynamical variables.

What are the limitations to the approaches we have developed these past two chapters? We have mentioned some of these before, but it is good to emphasize them again. We know from our prior studies in chemistry and from some of what we have done in this course, that strange things begin to happen when the systems we are studying get very small, the size of molecules and atoms. Energies become quantized. Atoms and molecules can absorb and emit only certain amounts of energy, not a continuous range. We saw how specific heat modes became frozen out at low temperatures in solids. Things also get weird when speeds become large. In this case, large means moving at speeds that begin to approach the speed of light. Both at very small scales and when things go fast, some of our models break down and must be replaced by more complicated theories. But the primary variables in both quantum mechanics and in special relativity turn out to be energy, momentum, and angular momentum. There is something very special about these quantities. They apparently represent some of the most basic aspects of the universe. The fundamental ideas of conservation of energy, momentum, and angular momentum carry through all of the models we use to describe our universe.

The concepts of energy, momentum, and angular momentum (and the conservation of energy and momentum) remain as we delve into the details of the microscopic and the realm of very high speeds, but we do have to make changes in our understanding of these concepts. Energy, momentum and angular momentum take on discreet values; i.e., they become quantized. When we go to high speeds momentum and energy become intertwined. Even the separate idea of mass conservation gets pulled into a unified mass-energy conservation principle. We will explore the quantum world a little further in Physics 7C, but you will need to explore the fascinating world of special and general relativity on your own or in more advanced courses.