Research Interests

There are two main branches to my research interests. The first is *collider phenomenology*, spanning aspects of collider searches such as Higgs bosons, Supersymmetry, Dark Matter. I am interested in designing new experiments and analyses which probe new phenomena, whatever that phenomena may be. In the past several years I have explored aspects of dark matter, including a very successful program at B-factories to search for dark matter with a mass $M < 5$ GeV and Higgs bosons with masses $M < 9$ GeV.

The second major interest is *particle cosmological relics*, which overlaps with collider searches in the form of "dark matter". I am extremely skeptical that the observations such as flattened galactic rotation curves are due to a new particle, which has driven my projects to find ways that could prove dark matter is *not* present; a more difficult question than considered by most. I am more certain of the existence of neutrinos, and in particular the relic neutrino background. This is largely unexplored territory and has forced me to learn many new subjects to appropriately describe the "condensed matter" dynamics of this system.

Collider Phenomenology

I carried out a very successful program searching for low-mass Higgses and dark matter starting in 2005. I investigated natural ways to have light Higgses in the NMSSM, extended SUSY models, and the Gaugephobic Higgs model, as well as model-independent considerations of quarkonium decays to dark matter. In these papers I proposed several experiments that can be done with low-energy e^+e^- data. This led directly to numerous experimental searches at BaBar, Belle, BES, and CLEO, as well as new runs on the $\Upsilon(3S)$, $\Upsilon(2S)$, and $\Upsilon(1S)$ at BaBar and Belle as a direct consequence of my work. No Higgses or dark matter were discovered, but the ground state of bottom quarks, the η_b was discovered using data from these new runs. I actively communicated with experimentalists on these experiments, as I believe science progresses faster and better with a tight coupling between theory and experiment. This work is drawing to a close, with the end of data taking at BaBar and Belle. New publications are still expected, but in the absence of a discovery, all eyes now turn to the LHC. I am however still participating in motivational work for a Super-B factory.

In 2007 I began as an effort to measure spin at the LHC, which has turned into a very general, and extremely powerful technique for data analysis in events with missing energy at any collider. These techniques can be regarded as using the Matrix Element methods pioneered in $t\bar{t}$ searches at Fermilab, and applying those techniques to other new particle searches involving missing energy. This imposes significant restrictions on the interpretation of the data and leads to a hypothesis-testing approach. I am actively collaborating with experimentalists in this area to develop a body of code capable of creating and solving these systems of polynomial equations that arise, that can be used by experimentalists and theorists alike. This research program is ongoing with several current and upcoming projects. I also eagerly await discoveries from the LHC and Tevatron, and will carefully examine any new discoveries or anomalies as they appear.

Particle Cosmological Relics.

The question of what relic neutrinos are doing has been an obsession of mine since graduate school. I have taken the approach of describing relics using a quantum condensed matter inspired approach, or effective field theory, rather than using the classical Boltzmann equation. The non-classical consequences of relics include that they contain long-range goldstone acoustic quasi-particle excitations, the dynamics of which form a new effective field theory with long-range forces and neutrino masses due to Pauli blocking. Due to the presence of a spin-2 mode I called this "Emergent Electroweak Gravity". A major topic of my research in coming years will be to determine what the cosmological and neutrino experiment consequences of these observations are, and whether it could actually be the gravity we observe.