Research Interests

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Twice in the last two years I have had the opportunity to teach introductory astronomy, and both times, even as I was teaching the subject at a mostly non-mathematical level, I was reminded that modern astronomy requires me to dust off and apply all that I know about theoretical physics and then some. Teaching astronomy was also personally fascinating and inspiring. Most recently, while teaching astronomy in the Fall 2016 term, I was also struck by what a superb vehicle for practicing and communicating the scientific method the subject represents. As a result of these experiences, I have spent much of my spare time in the last several months figuring out how I can meaningfully leverage my background and Saint Mary's resources into a compelling astrophysics research program.

Astronomy has entered the age of large surveys, with many consortiums fielding space- and ground-based instruments that can robotically photograph all of the sky that is visible to them every night. The size of the charge-coupled devices (CCDs) attached to these telescopes are measured in gigapixels (not megapixels like the 3 megapixel CCD currently attached to the Geissberger). This sounds like a death knell. What is left for a physicist at a small college with access to a few telescopes and a passion for particle physics and astrophysics to do?

The surprising answer is, provided he or she is willing to roll up his or her sleeves, *more than ever*. Furthermore, the Saint Mary's Physics and Astronomy Department already has the equipment to complement the work of the large surveys. Our equipment can do this by quantitatively measuring subtle changes in the brightness of individual stars. Historically, such measurements were used to establish cosmic distance scales, including the discovery in 1924 that our galaxy was just one of many, and the discovery in 1929 that the universe is expanding.

Today, similar techniques, but now using CCD cameras instead of photographic plates, are being applied to much smaller brightness changes and are being used to study many subjects, including the rapidly expanding catalog of planets found around other stars. As the exoplanet catalog grows, a small subset of stars known as "dippers" whose planetary systems are still in formation are being identified. Just as the Earth regularly crosses the face of the Sun when viewed from Jupiter, clouds of proto-planetary material cross the face of other stars. By studying the resulting brightness curves, the structure of the proto-planetary disks can be computed and their evolution can be modeled.

For decades, networks of astronomers with small telescopes have been collectively following the most interesting targets they can mutually identify. The American Association of Variable Star Observers (AAVSO) is the best-known of these networks and is welcoming of participation by modest but serious individuals and small teams. It is well within our reach to understand, operate and calibrate our equipment so that it is meaningfully contributing to the large-scale surveys and their follow-up networks. This is so promising that I have no qualms about pitching it as my future direction despite being a newcomer to observational astrophysics and the specialty of CCD photometry.

Furthermore, it is ideal for student-centered research (where students deepen their interest and understanding of a subject while doing research in it). For many students, including many very intelligent and dedicated ones, the traditional cycle of studying textbooks, going to lecture, doing problem sets and taking exams never ignites. My younger brother was one such student who was losing his way in electrical engineering until Prof. Eric Adelberger, who was building a gravitational wave detector at the edge of the University of Washington campus, asked him to start building circuit boards for the experiment. Once my brother had his hands on actual circuits, his understanding of electrical engineering took off and he was able to catch up and excel in the remaining two of his undergraduate years.

Obviously, someone with long-term responsibility for the care of the equipment, for beating down experimental error, and for choosing general research directions needs to have a leadership role, but if that context is provided, then there is a whole sky full of newly identified observing targets waiting for interested and patient undergraduates to observe and understand. For additional detail on this program, see the course description for independent study and research with two Saint Mary's seniors, Katherine Damiano and Justin Robinson, on-line at http://physics.stmarys-ca.edu/courses/Phys185/17S.

On the theoretical front, my long-term hope is to combine my knowledge of field theory and experience with numerical simulation gained while doing research in particle physics and lattice gauge theory with my professional experience in software engineering, and to begin contributing to computational physics again. Likely I would work in the area of simulations of planetary formation. First, this interests me strongly from a physics standpoint, and second, it would directly inform and be informed by the observational astrophysics program described above.