BURCH FELLOW 2008

JONATHAN TOLEDO
Class of 2009
Sylva, NC

Jonathan Toledo

There is a physical principle stating that, given some initial state, a macroscopic mechanical system will move into a final state in such a way that a very special quantity is minimized. At the risk of being metaphysical, I must admit that I find myself wondering what quantity is minimized (or perhaps maximized) during the movement of our own lives and interactions with other people. And thus when I found myself at the age of 20 standing in the middle of the Barajas International Airport – just a short subway ride from the center of Madrid, Spain, and thousands of miles from my home in the heart of the Great Smoky Mountains of Western North Carolina, I naturally found myself wondering what possible orderly physical law could be behind the seeming randomness of life.

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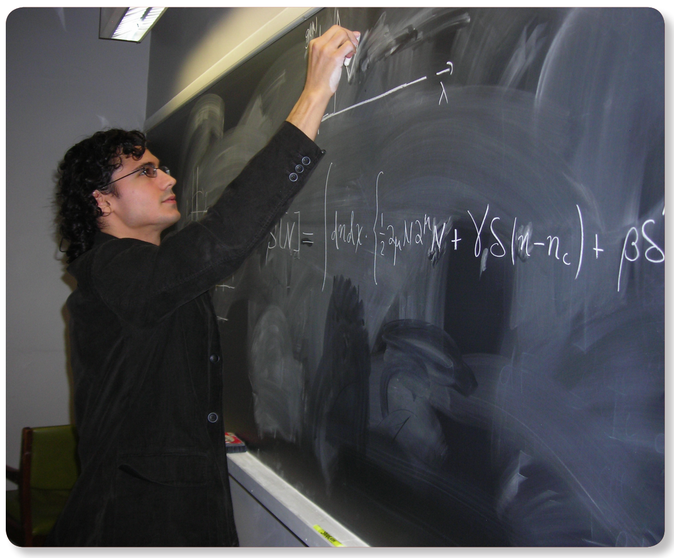
# A SUMMER IN MADRID: A STATIONARY PATH, OR A SUM OVER ALL?

I had been brought to Madrid through my recent studies of the remarkable material Graphene. Graphene is a special case of a material that we are familiar with from everyday life – graphite (the substance that comprises pencil "lead"). Graphene is the 2-dimensional form of graphite in the sense that graphite is formed when several layers of graphene are stacked upon one another in a specific way. Despite its appearance as a rather ordinary substance, graphene exhibits a host of remarkable properties due to its low dimension and the symmetry of its crystal lattice. One of the most incredible features of graphene is that phenomena familiar to seemingly estranged areas of physics (e.g. ultra relativistic quantum mechanics, field theory, and even quantum gravity) are predicted to be present (effectively) in graphene in a measurable way.



Specifically, I had come to Madrid to work with Professor Maria Vozmediano of the Madrid Institute of Materials Science ('the Institute') – a string theorist of yore, and one of the original contributors to the theoretical study of graphene. Maria had been studying how curvature affects the electronic properties of graphene – an area of study where one borrows the mathematical machinery of general relativity (designed for describing processes in curved spaces), the theoretical spirit of quantum field theory (the framework describing very small objects moving near light-speed) and mixes them all together to arrive at a truly remarkable way of describing a flake of ordinary pencil lead.

Coming out of a year packed with graduate courses from general relativity to quantum field theory, I thought that I was ready to jump into the ring and duke it out with the toughest of problems in graphene-physics – and I had written a proposal to do just that. But alas, it was a K.O. in the first round. After arriving in Madrid and falling under the all-knowing and brutal scrutiny of Maria, it was found that I was still too green to take up the proposed challenge. Though greatly disappointed, all was not lost. We decided to look at the situation as more of an opportunity than a set-back, and Maria adopted me as a student for the summer.

In those first weeks my summer had taken a dramatic turn from the planned course, and I found myself in a rather unexpected though still ideal situation. While I wasn't making revolutionary discoveries in graphene-physics, I was given the golden key to the Institute – I had access to any of the Institute's academic resources, and most importantly, their people. I had routine meetings with Maria, who helped me to outline a study plan and guided me as I went along, and in a sense I was adopted as the student of the entire theory group of the Institute. The group's many highly trained and energetic graduate students and post-docs were always more than willing to answer questions that came up during my studies and to offer their own experience. By the end of the summer, though still not ready to jump into theoretical research, I had grown enormously as a theoretical physicist. Scientifically, the entire experience was invaluable for only a few discussions with Maria regarding the relation between quantum mechanics and statistical mechanics via the so-called Path Integral, which allowed me to make the first steps in a research problem that had been stuck in the back of my mind for almost a year at that point.

The final ingredient was my trip to the tiny, ancient city of Camarino – located southwest of Ancona, Italy. Using a Eurail-Pass, I traveled up to Barcelona, through southern France including Montpellier, Marseille and Monaco, and then down to Camarino via Milan. Having spent nearly my entire life in the mountains of western NC, and having never been out of the country prior to that summer, the experience was truly mind-blowing. My purpose in going to Camarino was to attend a conference on systems interacting via coulomb forces (the SCCS), where an entire day would be devoted to graphene. While at the SCCS, I attended presentations by some of the worlds leading experts on the experimental and theoretical aspects of graphene, including Eva Andrei and Milhail Katsnelson.

Like any other transforming experience in my life, my Burch fellowship was far from an easy one, and at times downright tough. And yet the personal and scientific growth that I have gained in return makes the opportunity truly irreplaceable. And – as I believe is true for any Burch fellowship that has been, and any that will be – the experience continues to teach me new lessons as it unfolds.