COLLEGE OF ARTS AND SCIENCES

Department of Physics

Date: Tuesday, October 30, 2018
To: Search Committee
Subject: Application for Associate Professor at the Texas Tech

Enclosed is my application for the open faculty position in the Department of Physics at the Texas Tech. I am currently an Associate Professor at the University of Alabama at Birmingham in the Department of Physics, with a secondary appointment in Electrical Engineering. I was promoted and tenured (October 2013), having joined the faculty in August 2007 as an Assistant Professor. In addition to this cover letter, my application includes a detailed vitae with a listing of publications, statements of research plans and teaching philosophy, and the names and contact information of professional references. My interest in Texas Tech is the opportunity to grow my existing research program in strongly nonequilibrium systems as well to integrate it in the broader research environment at Texas Tech. Aside from the existing condensed matter groups in physics, this would allow me to collaborate with other ultrafast research groups in the Nanotech center in Engineering as well as the extensive growth, characterization, and fabrication equipment in the Nanophotonics Center.

My research focuses on the physics of two-dimensional materials in gallium arsenide, with a recent expansion to include the emerging class of 2D and layered dichalcogenides. My research group has led the development of high magnetic field ultrafast spectroscopy research at the National High Magnetic Field Laboratory at Florida State University. Our recent research has focussed on the physics of two-dimensional electron systems in the high magnetic field and low temperature limit. The experimental technique that we have developed is the study on ultrafast time scales of the electronic and optical properties of materials in the 25 Tesla Split Florida helix magnet system at the National High Magnetic Field Laboratory at Florida State University. Our recent submission to NanoLetters (under review), which is currently under review, provides new insight into the role that quantum confinement has on superradiant emission in these systems. Our results show that the strong confinement surpasses this effect and our supporting DFT calculations show that this effect is closely related to the strong enhancement of the density of states in 2D versus 3D.

Another recent Review of Scientific Instruments publication describes the development of an entirely novel research tool in my group to perform ultrafast spectroscopic measurements at previously inaccessible magnetic fields as high as 25 Tesla using the new Split Florida-Helix magnet at Florida State University. To the best of our knowledge, this magnet is the only one available that has the needed optical access to these high magnetic fields. My current funding is a new Department of Energy/Experimental Condensed Matter Physics grant that focused on strongly non-equilibrium physics in Iron-based superconductors. These well-known superconductors show strong phase competition between the superconducting and magnetic order. Our proposal is to use ultrafast lasers along with our unique high magnetic field to design optical pulse excitations to control the electronic phase. Our combined theory-experimental collaboration focusses on the central hypothesis of our proposal: spin correlation is at the core of exotic emergent properties, including high-T_c superconductivity, in diverse quantum materials including the iron pnictides as well the copper oxides. Our idea is to optically steer novel emergent properties and hidden phases by nonlinear driving of fundamental elementary excitations and their interactions using repeated femtosecond control of coherent and non-thermal carriers and spins during laser excitation. With versatile coherent control by pulse-trains, we aim to modify quasi-particle spectra, generate forbidden admixtures of order parameters, and control quantum oscillations between different phases of highly correlated materials, on a timescale even shorter than the fundamental order parameter variation time. Of particular interest is the collapse and revival of the order parameter following all-optical quantum femtosecond quench through a quantum critical point.

A second focus of our research is on the physics of photoinduced phase transitions of the well-known electronic and structural phase transmission in vanadium dioxide. This material undergoes a first-order phase transition at 340 K from a monoclinic-insulating phase to a rutile-metallic phase. The

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significant feature of the insulating phase is the tilting pairing of vanadium dimers in the semiconductor phase. The open question in this system is the relative significance of the structural distortion (Peierls) and electron correlations (Mott), which makes this material an excellent model system to elucidate the influence of Coulomb repulsions in condensed matter systems, with a particular focus on disordered systems. This work is a collaboration between my research group and Prof. Haglund at Vanderbilt University, with recent articles [K. Appavoo, *et al.*, Nano Letters 14, 1127 (2014) and Brady, *et al.*, J. Phys.: Cond. Matt. 28, 125603 (2016)], several conference proceedings, and presentations.

Undergraduate and graduate student training is a main broader impact of my research program. Undergraduates, in particular are direct participants in all aspects of my research program, including experiments conducted at the National High Magnetic Field Laboratory. My current research group includes two graduate students, and three undergraduate students. Since coming to UAB, I have graduated multiple Ph. D. students and masters students to degree completion, and have a strong track record mentoring undergraduate research, as well. Recent placement of my undergraduate students has included Luke McClintock (Goldwater Scholarship, 2015) who is now a third year graduate student at UC Davis. A more recent undergraduate student, Mr. Aidan O'Berine, was honorable mention for the Goldwater in 2016 and is now a second year gradate student at Stanford. Other undergraduates that have completed their 4-year degree while conducing research in my lab have been placed in a PhD programs at Mississippi State, and Colorado-Boulder, masters program at Free University of Berlin and UAB, or enrolled in UAB medical school.

My teaching while at UAB includes a mix of graduate and introductory classes, with IDEA survey score averages in introductory classes rising from 3.5/5 (adjusted) in 2010 to 4.6/5 (adjusted) in my most recent semester (full details can be found on my CV), while my graduate IDEA scores rose from 4.4/5 (adjusted) to 4.7/5.0 (adjusted) over a similar period. My initial assignment was to redevelop the two-semester Jackson Electricity and Magnetism sequence for UAB's physics graduate students. This class had been previously taught at UAB in a very traditional didactic lecture. Specific problems that UAB students have with this material are the result the mathematical complexity of these problems, which are difficult for students visualize and understand the underlying physics. I introduced a new component, in class and in homework, of computer visualization and finite element analysis software to aid in this visualization to enhance conceptual understanding.

I currently teach our honors introductory physics sequence, which is now in its seventh year. This is a new honors college class that I have created to fill a need at UAB and to grow ties between the Department of Physics and the growing Honors College at UAB. This class uses a combination of material drawn from Knight, Halliday and Resnick, Fundamentals of Physics, and Kleppner and Kolenkow, Mechanics. The main challenge has been adapting the content of these to our high performing students, who are almost exclusively considering future medical careers. I have developed my own lecture notes with a focus away from the traditional engineering examples of these books and with new examples based on biomechanics. I am transitioning this class from a standard dyadic lecture-based format to an interactive classroom that reflects the growing body of work in physics education research as the appropriate facilities at UAB for this become available. I am aware of the existing infrastructure at Texas Tech for this and would work closely with existing faculty to implement this in my own classes.

My service activities have focused on developing programs that enhance UAB's mentoring of junior faculty and on outreach to traditionally underrepresented minorities within the greater Birmingham community. UAB is ranked near the bottom of the Carnegie Foundation's list of "*Very High Research Activity*" universities for the number of NSF CAREER awards; my own award in 2010 was only the 5th award to a UAB faculty member since the program began. A significant reason is an underdeveloped mentoring system at UAB to assist new junior faculty in the development of this proposal. To remedy this, Tony Skjellum (the then-chair of UAB's Department of Computer Science) and I developed a seminar series to train new junior faculty with to prepare their proposal develop their education and outreach plans, identify mentors within their research field, and on general grantsmanship skills. Since its inception in its current form in 2011, this has led to a growing cadre of CAREER winners at UAB and a

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substantial increase in the number of junior faculty that apply to this program. While UAB's situation was somewhat unique when I arrived, it would be my intention to contribute to existing efforts or to develop similar programs to those currently at UAB should I join the faculty at Texas Tech.

As part of the broader impacts for my CAREER and other NSF awards, I have established a new summer outreach program to recruit rising ninth grade students from traditionally underrepresented groups in the Birmingham area into STEM careers. Physics Bridge provides participants with an exciting experience in optics, lasers, and light by conducting hands on experiments working with UAB faculty, students, and staff to understand physics. Approximately 40% of schools in Alabama do not offer their students physics classes and this is particularly true in minority-serving school systems in Central Alabama. Our outreach program gives students without local options an opportunity to explore optics, physics and astronomy that would not otherwise be available to them.

In the first eight years, approximately 70% have been African American and have included a majority of female participants. At Texas Tech, I would adapt this outreach program to the students at Texas Tech and the greater Lubbock community. I note from Texas Tech's website[1] that approximately 30% of the students identify as Hispanic and that the local community has similar demographics according to 2010 census data, so I believe that a similar program at Texas Tech could be an important component of providing opportunities to Hispanic students, in particular, and increasing the number of physics majors in the department using this model. Physics Bridge at UAB has proven to be both an important service to the local community and, now that the first cohorts of students are applying to college, it is also proving to be a new recruiting tool for our undergraduate major.

I believe that my teaching and research programs are an excellent complement to the ongoing work at the Texas Tech and will provide an excellent opportunity to grow my own program, as well. I have asked that several colleagues, including Dr. Steve McGill (mcgill@magnet.fsu.edu), Prof. Richard Haglund (richard.haglund@vanderbilt.edu), and Prof. H. Christian Schneider (hcsch@physik.uni-kl.de), provide your committee with letters of reference at your request. I look forward to speaking with the search committee about this position and any questions that you have about my research program and about me. Please contact me on my cell phone (585) 662-3571 or through my email account (davidhilton1@gmail.com) with any questions that I may be able to answer for your committee.

With best regards,

David J. Hilton

[1] http://techdata.irs.ttu.edu/Factbook/Enrollment/ENRETHCLASS.aspx

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