MACALESTER

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Dr. Sean Bartz, Visiting Assistant Professor
Macalester College

Dear Committee Members:

I am writing in application for the position of assistant professor of physics at Indiana State University. Since earning a PhD in physics from the University of Minnesota in 2014, I have worked as a visiting assistant professor at Macalester College. My research program investigates strong coupling in nuclear matter using extra-dimensional theories and numerical calculations, and my undergraduate researchers have co-authored articles and presented at national conferences.

My teaching emphasizes conceptual discussion and group problem solving, with opportunity for feedback and additional attempts to solve problems. Shortly after I introduce the material, students work on context-rich problems designed to get them thinking about what assumptions to make and concepts to apply. Using a smartphone polling app, I ask conceptual questions and allow student responses to guide further discussion. I incorporate computation at all levels, attending workshops to develop this curriculum. I share the computational activities I develop through online resources and at the AAPT Summer Meeting. Introductory students learn the power of computation to extend their textbook problems to real-world applications, such as modeling the effect of drag on the projectile motion of a golf ball. Upper-level students develop computation as a complement to theoretical and lab techniques. I developed a lab where students use numerical solutions to Laplace's equation to calculate capacitance and compare to their measurements.

I foster respectful and productive learning environments for a diverse student body through teaching and service. As an Allies Project member, I learn about the barriers students face due to gender, sexual orientation, race, and socioeconomic status. I incorporate techniques, including group discussion and problem solving, which are shown by education research to mitigate barriers for populations underrepresented in physics. I invite struggling first-year physics majors in my introductory courses to visit my office more often, providing extra instruction and study tips, helping them succeed. My volunteering for the Minnesota Science Bowl and the Tennis2College program has been focused on encouraging young people to develop an appreciation for science and view it as a possible career path.

My research investigates strongly-interacting nuclear matter, a regime where traditional quantum chromodynamics (QCD) cannot accurately describe quark-gluon interactions. At the extreme temperature and density achieved in heavy-ion collisions at Brookhaven National Lab, nuclei melt into a strongly-coupled quark-gluon plasma (QGP). I model the properties of the QGP using a conjectured equivalence between strongly-coupled quantum theories and weakly-coupled gravity theories with an extra dimension. Using the more-tractable gravity theory, known as "holographic QCD" because of its extra dimension, I predict the phase boundary between ordinary nuclear matter and the QGP. Holographic models also describe energy levels of bound states of quarks known as mesons, a different strongly-coupled regime of QCD. My dissertation research solidified the theoretical foundations of a particular holographic model of well-measured meson states.

Holographic QCD can interpret and guide current nuclear physics experiments in contexts where traditional QCD and supercomputer techniques fail. Traditional QCD methods work well for the weak coupling found in the high-momentum collisions of the Large Hadron Collider, but fail to calculate the energy levels of particles at rest. My dissertation research, published in two articles in *Physical Review D*, illustrates the power of holographic models in this regime. Lattice QCD is a powerful supercomputer technique, but extending to high quark density is a stubborn problem. I used a holographic model to study the effects of high density, detailed in an article in *Physical Review D* co-authored with an undergraduate advisee. We map the complete phase diagram, finding the critical temperature and density of the phase transition to QGP.

Undergraduate researchers play an ongoing role in my two main lines of research on holographic QCD. The next experimental run at Brookhaven will focus on finding the expected critical endpoint in the boundary between the plasma phase and ordinary nuclear matter, so using my holographic model to make a robust prediction of its location is a timely objective. In a separate collaboration I am exploring the results of my dissertation research when all quarks are removed, leaving only gluons. This will allow the prediction of the energy levels of hypothesized glueball particles sought at Jefferson National Lab. In addition, traditional QCD methods can make predictions for such "pure glue" models, which will allow for an important check on the holographic results. In the longer term, I plan to solidify the theoretical underpinnings of thermal holographic models, in a similar vein to my dissertation research on the zero-temperature version.

The departmental focus on student research makes the position at Indiana State particularly appealing. I am excited to teach students with a variety of interests and levels of preparation. I anticipate continuing to teach across the curriculum, including introductory physics and liberal arts core courses for non-science majors. I envision teaching a topics course on particle and nuclear physics or computational physics. My research is well suited to introduce students to nuclear theory, an exciting field that is often inaccessible before graduate school, and would complement existing departmental research in nuclear experiment. I plan to continue advising students in projects will lead to publications and conference visits as students develop transferable computational skills.

Thank you for considering my application. I look forward to hearing from you.

Sincerely,

Seán P. Bartz

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