Reason for Participation (maximum 4000 characters):

I aim to better understand the current challenges in theoretical physics and obtain the tools to confront them. I believe that my background in mathematical physics will allow me to make the most of the lectures provided guaranteeing a successful and enjoyable experience. In particular, I am very excited about the lectures on topology for physicists. This is an immensely important subject in modern theoretical endeavors which is usually forgotten at the undergraduate level. On the other hand, the other set of lectures will provide me with the chance to learn more about many subjects which are in constant contact with my current research. Indeed, algebraic formulations provide a more structural understanding of topics such as field theory and phase transitions. Examples can be found in the Haag-Kastler axioms and the application of index theory to the topic of topological phases.

In the additional information and summary sections I list why I believe I have the right prerequisites to assist to this school. However, I also believe that this is a great chance of getting immersed at the international scale with the theoretical physics community. In particular, I am excited to get to know colleagues with similar interests who may eventually turn into collaborators. This is an opportunity to consolidate a network of Latin American physicists that will make our continent a force to be reckoned with at the frontiers of theoretical physics.

I am also very interested in the SAIFR-Perimeter Fellowship. Ever since I first started watching Professor Carl Bender's lectures on mathematical physics online I knew that I wanted to do graduate school at the Perimeter Institute for Theoretical Physics. I believe this joint masters program would be an amazing opportunity to consolidate my knowledge of modern theoretical physics and continue my career as a researcher.

Additional Information (maximum 4000 characters):

My research is based on the applications of geometric, algebraic and topological methods for physics. In particular, I am interested in the applications that algebraic formulations of physics may have in better understanding the inner pinnings of Quantum Field Theory. I believe that the power in these formulations lies in the clearness and transparency of the physical and mathematical interpretations of the objects it involves.

During my undergraduate thesis I worked on KMS States and Tomita-Takesaki Theory. Here I studied how thermal equilibrium finds a natural formulation in the framework of algebraic quantum physics through the KMS condition. Moreover, I learned how the modular theory of Tomita-Takesaki allows us to construct a dynamical law from a normal faithful state which guarantees that the state is in equilibrium. This shows that there are equilibrium induced canonical dynamics and elucidates the relation between temperature and complex time.

I am currently on the first semester of a masters program as a graduate assistant at the Universidad de los Andes. My research has now shifted towards the calculation of entanglement measures for general algebraic states. As it turns out, calculation of entropy through the GNS construction is ambiguous. We are currently trying to understand how one can relate such ambiguities to the modular operators of Tomita-Takesaki and the relationship this phenomena has with quantum anomalies and information theory. In particular, the relationship between Radon-Nikodym cocycles and derivatives may provide a better understanding of the anomalous behavior of path integral measures through Tomita-Takesaki theory.

Outside of theoretical physics, I've previously worked with electrochemically exfoliated graphene and infrared sensors. Doing the latter, I was an Summer Undergraduate Research Fellow at the California Institute of Technology during the summer of 2017. In here I collaborated with JPL NASA researchers in the Precision Projector Laboratory. We studied motions in the centroid of images taken in simulated environments to improve the testing of infrared sensors. The sensors we studied are scheduled to be part of missions such as WFIRST and EUCLID.

Justification for Financial Request (Maximum 400 characters):

I've recently moved away from my family home to relieve the financial stress off of my parents. Thus, I do not currently own any personal or family funds. On the other hand, I was unable to obtain assistance from my university due to recent budget cuts and financial reforms. Obtaining funds for reasearch purposes in Colombia has become increasingly difficult.

Summary:

About me

Born on December 26, 1996 in Bucaramanga, Colombia, I've always been characterized by my strong passions. My first discoveries on symmetry through music laid the basis for my passion to understand what surrounds us. Physics has offered me a path through which I can explore the world making use of my creativity. At this point in my life I've decided to take advantage of every chance I get along the way to learn new things, meet new people, and become a better person. I am certain that the success of this enterprise will be guaranteed by the discipline and commitment I give to my work.

Special Skills

Theoretical Physics: KMS states, algebraic quantum field theory, global methods in general relativity, and geometric, algebraic, and topological methods in physics.

Mathematics: Algebra, Topology, Analysis, Measure Theory, Algebraic Topology, and Tomita-Takesaki Theory

Programming: Unix/Linux, Java, Python, and C

Experimental Physics: Infrared sensors and electrochemically exfoliated graphene.

Languages: Spanish and English (TOEFL 113/120). Three semesters of german studies.

Education

Physics Master

Universidad de los Andes

Expected: December 2019

Physics Major

Cum Laude

Universidad de los Andes, Bogotá, Colombia

Mathematics Minor

Thesis: KMS States and Tomita-Takesaki Theory

March 2018

Average: 4.72/5

Highschool degree: Academic Bachelor

San Carlos School, Bogotá, Colombia

June 2014

Awards

Cum Laude for graduating with a GPA in the best 3% of the science faculty in the past 5 years.

Semiannual Excelence Prize for the best grades on the first semester of 2017 of the Physics department at the Universidad de los Andes.

Ramón de Zubiría Prize for the best global grades up to the first semester of 2016 of the Physics department at the Universidad de los Andes.

Semiannual Excelence Prize for the best grades on the second semester of 2015 of the Physics department at the Universidad de los Andes.

Honorable mention in the 45th International Physics Olympiad (Kazakhstan 2014).

Third place in the Colombian Physics Olympiad of 2013.

Experience

SURF California Institute of Technology: I worked under the supervision of Dr. Roger Smith and Dr. Andrés Plazas during the summer of 2017. I aided the investigation, characterization, and correction of image centroid motions at the Precision Projector Laboratory in the Jet Propulsion Laboratory (NASA). The detectors investigated will be used for the study of weak gravitational lenses and dark matter in missions such as WFIRST and Euclid.

Graduate Assistant at the Universidad de los Andes:

Physics 1 recitation in the first semester of 2018.

Basic Physics 1 recitation in the first semester of 2018.

Teaching assistant at the Universidad de los Andes:

Lineal Algebra 2 with professor César Galindo in the second semester of 2016.

Physics clinic in the second semester of 2016.

Linear Algebra (Honors) with professor Sergio Adarve in the first semester of 2016.

Tutor: I have helped students of Physics 1, Physics 2, Integral Calculus, Vector Calculus, Linear Algebra 2, and Mathematical Methods.

Seminars

Topological Order and Beyond: KMS States and Tomita-Takesaki Theory

Universidad de los Andes, Bogotá, Colombia

May 2018 (already confirmed)

Quantum Field Theory and Mathematical Physics Seminar: Algebraic framework for classical and quantum physics through $C^\*$-algebras.

Universidad de los Andes, Bogotá, Colombia

February 2018

Quantum Field Theory and Mathematical Physics Seminar: Orthocomplemented Quantum Lattices of Propositions.

Universidad de los Andes, Bogotá, Colombia

April 2017

La Cicuta Magazine 7th edition release: On the Communication and Censorship of Science.

Universidad de los Andes, Bogotá, Colombia

September 2017

Seminars Attended

Topological Order and Beyond

Universidad de los Andes, Bogotá, Colombia

May 2018

Dynamics of Quantum Systems Outside of Equilibrium

Universidad de los Andes, Bogotá, Colombia

December 2017

URDiplomats workshop

Universidad del Rosario, Bogotá, Colombia

April 2014

Extracurricular Activities

Tutoring at the Iglesia de Nuestra Señora de las Aguas for the state exam. This was targeted at low income teenagers of La Candelaria neighborhood.

Guitar classes targeted at low income teenagers. This was part of my social service at high school.

Elected president of the student council at Colegio San Carlos during my senior year.

I teamed up with the United Nations Information Center to design the first UN model at a citywide scale SIMONU 2013. I also acted as the Secretary General of the UN model of my school SACMUN X and performed as president and delegate of various other models in Bogotá.

References:

Prof. Andrés Fernando Reyes Lega: anreyes@uniandes.edu.co

Dr. Roger Smith: rsmith@astro.caltech.edu

Dr. Andrés Plazas: andres.a.plazas.malagon@jpl.nasa.gov

Prof. Carlos Andrés Flórez Bustos: ca.florez@uniandes.edu.co

Prof. Sergio Adarve: sadarve@uniandes.edu.co

Prof. César Neyit Galindo Martínez: cn.galindo1116@uniandes.edu.co