
70 Vassar Street, Room 37-675
Cambridge, MA, 02139

Cell: [REDACTED]

Office: [REDACTED]

E-mail: [REDACTED]

Dear Origins Prize Committee:

I am writing to apply for the the inaugural Origins Postdoctoral Prize Lectureship sponsored by the Epstein VI Foundation as part of the Origins Project at Arizona State University. I am currently a Pappalardo Fellow and NASA Einstein Fellow in the Department of Physics at MIT and the MIT Kavli Institute for Astrophysics and Space Research. My research areas include high energy astrophysics, dark matter searches, and cosmology. I respectfully submit my supplemental application materials for your consideration with my great interest. In this cover letter, please allow me to address the connection between my research and the interests of the Origins Project.

Origin of the Fermi bubbles and the super-massive black hole at the center of the Milky Way

Our home galaxy, the Milky Way is full of surprises. My Ph.D. thesis is on the discovery of the *Fermi bubbles*, a pair of unanticipated gigantic bubbles extending ~ 50 degrees above and below the Milky Way's galactic plane. The whole structure has a size of 50,000 light years comparable to the size of the Milky Way itself, and emanates very high energy gamma-ray photons up to hundreds of billions of electron volts. These spectacular mysterious bubbles hint at a powerful event that took place millions of years ago. *The origin of the Fermi bubbles is closely related to the origin of the super-massive black hole at the center of our galaxy.* They are most likely created by some episode of large energy injection from the center of the Galaxy, possibly through a gigantic belch of the super-massive black hole. The central black hole might have accreted an enormous amount of gas and dust - perhaps several hundreds or even thousands of times the mass of the sun. The study of Fermi bubbles not only provides crucial information about the structure itself, but also shed light on emergent key problems including black hole activity in the Galactic center, and may offer insight into the evolution history of the Milky Way itself. This work has been recently awarded the *Bruno Rossi Prize* by the American Astronomical Society, and I'm the youngest prize winner since the award's inception in 1985.

Origin of the Universe: looking for the primordial gravitational waves from the very beginning

Almost 14 billion years ago, the universe we inhabit burst into existence in an extraordinary event that initiated the Big Bang. The theory called *inflation* states that in the first fleeting fraction of a second ($\sim 10^{-35}$ second), the spacetime of our universe expanded exponentially, stretching far beyond the size of the observable universe at that time. It explains the origin of the large-scale structure of the cosmos. Quantum fluctuations in the microscopic inflationary region, magnified to cosmic size, become the seeds for the growth of structure in the Universe, including galaxies, stars, and planets like the earth. However, the theory has never been approved observationally for more

than 30 years. The gravitational waves produced during the inflationary phase squeeze space as they travel, and this squeezing produces a distinct pattern in the cosmic microwave background (CMB) – the faint after glow from the Big Bang when the Universe was a smooth hot plasma. *By studying the CMB we can learn much about the origin, contents, and ultimate fate of the Universe.* Since 2009, I have been working on the BICEP (Background Imaging of Cosmic Extragalactic Polarization) experiment located at the Amundsen-Scott South Pole Station of United States in Antarctica, which is an experiment designed to measure the B-modes (so called curl component) of the polarization of the CMB predicted by the inflation theory. I worked on the data analysis pipeline extensively, and I'm a leading author of the paper on the final results from the first generation of BICEP experiment after three years successful operation. In 2014, the second generation of the BICEP experiment announced the detection of the B-mode polarization of CMB, *a possible signature of inflation in the very early Universe.* This work offers new insights into some of our most basic questions: Why do we exist? How did the universe begin? These results are not only a smoking gun for inflation, they also tell us when inflation took place and how powerful the process was. I have recently been proposing a site in Tibet for future CMB observations to cover the northern sky for the first time. It will provide unique opportunity to study the origin of the Universe. In addition to these observational works, I have also worked extensively on a variety of topics of theoretical cosmology.

Origin and nature of the dark matter

Dark matter is a substance hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes. Instead, the existence and properties of dark matter can only be inferred from its gravitational effects on visible matter, radiation, and the large-scale structures of the universe. In the past decades, we have learned that the amount of dark matter that exists is a factor of six more than that of ordinary matter in our Universe. The consensus among cosmologists is that dark matter is composed primarily of a yet uncharacterized particle. *The origin and nature of dark matter particle is one of the major problems in fundamental physics today.* I have been developing independent projects on indirect search for dark matter using gamma-ray, X-ray, microwave, and radio telescopes. I have led a couple of papers for the observational evidence of a gamma-ray line at ~ 135 GeV, which could only be produced by dark matter particles annihilate with each other, and these works received a large attention from the community. I co-led an effort to change the observation mode of the Fermi Gamma-ray Space Telescope over a year to hunt for this signal. Motivated by searching the dark matter signals, I have been studying the next generation of gamma-ray space telescopes, and leading a gamma-ray satellite called PANGU (PAir-production Gamma-ray Unit). After two dedicated workshops, my proposed mission has recently been selected as the only high energy mission in a future space mission program and will compete for the final selection. I have also involved in a couple of ambitious high energy space missions. The Dark Matter Particle Explorer (DAMPE) will be launched in October this year, and I'm leading the diffuse gamma-ray working group. As the *First Leader*, I'm also leading the gamma-ray astronomy working group for the future High Energy cosmic Radiation Detection facility (HERD), which will improve the capability of high energy gamma-ray detection by an order of magnitude than the Fermi Gamma-ray Space Telescope.

In addition to the research closely related to the Origins Project, I have been invited and contributed more than 130 conference, colloquium, and seminar presentations since 2011, and have built strong connections with a broader field and formed solid collaborative resources. I have also

served on several grant review panels for both NSF and NASA, and have been conference conveners and session chairs several times (I'm currently organizing two conferences). I'm a referee on most of the astronomy and astrophysics journals, as well as physics journals e.g. Physical Review D and Physics Letters B, and a member of APS, AAS, IEEE, and SPIE.

I'm truly passionate about sharing with students and general public both my knowledge of physics and astronomy as well as the enthusiasm I feel throughout my life. Not everyone has a chance to conduct research about the Universe, or even take an introductory astrophysics/cosmology course. After years, if one only remembers the names of a few concepts, they know nothing. What's important is to experience the milestones that human beings have achieved in understanding the Universe. Cosmology/Astrophysics deals with some of the most majestic themes known to science. It is the very special moment in the history that we are confidently talking about the evolution of the universe: the origin and evolution of other planets far away from our *Pale Blue Dot*; formation of stars, galaxies, and the elements themselves; the building blocks of the Universe even they are dominated by "dark components"; and how we confidently testing the universality of physical laws throughout the spacetime. I'm eager to deliver this picture to the audience, with the goal that they could learn something about the ways to understand this world and themselves, from trying to understand the universe itself; no matter what they will be doing next on this planet, having the magnificence of the Universe guiding their attitude of life. They might not remember all the details from the Big Bang to the accelerating universe, but walking through the interpretation of astronomical data and construction of the history of the universe using physical principles will surely be an unique experience in their life.

Enclosed please find my Curriculum Vitae including publications, conferences, speaking engagements, and my personal website indicated on the first page. I'm also attaching my proposal with the outlines of the planned departmental colloquia and larger public lecture. Please do not hesitate to contact me if further material or information is required. I very much appreciate for your consideration. I look forward to the opportunity to visit Arizona State University, and contribute with my honors to the Origins Project.

Sincerely yours,

Meng Su

