**Statement of Purpose** *Application: Ph.D. in Physics, Fall 2018*

**Po-Wen Chang**

How can relative motion influence the measurement of length and time? In order to comprehend such an exotic idea in special relativity, I conceived a 4-dimensional cube with its volume unchanged for all observers when I was in high school. I did not realize that my cube resembles the invariant until I learned about General Relativity in my sophomore year in university. Understanding physics with an intuitive picture was thrilling, and since I aspire to develop deeper insights into nature, I have been most drawn to **cosmology**, **particle physics** and **astrophysics**. This eagerness is what drives me to apply to the Ph.D. in physics at XXX University.

My competence in physics is evidenced by my academic performance in engineering and physics. For example, I received a Director’s Scholarship to do a Master’s in Physics at National Taiwan University (NTU), since I ranked among the top two students (out of 200+ applicants) in the graduate school entrance exam. In addition, my undergraduate training in Electronics Engineering meant that I excelled in programming and designing semiconductor devices. I was equipped with the skills to improve the ROOT algorithms for calibrating Germanium and Sodium iodide detectors with photon-emitting sources (e.g., Caesium-137, Americium-24) for the Taiwan Experiment On NeutrinO (TEXONO). TEXONO is a renowned experimental group on dark matter and low-energy neutrino detection led by Dr. Henry Tsz-King Wong at Academia Sinica (the most prominent academic institute in Taiwan). Throughout my master’s studies, I also took a substantial number of advanced courses in theoretical physics. I have benefited most from *Special Topics in Field Theory* taught by Prof. Pei-Ming Ho. In this course, I realized that Einstein’s field equations can be reproduced with alternative theories, even though they contain multifarious degrees of freedom at the off-shell level or high-energy regime.

Driven by the urge to know whether the alternative theories of gravity provide consistent interpretations for observational cosmology, I delved into the scalar-tensor (ST) theories as my master’s project. The ST theories are characterized with a non-minimal coupling (NMC) between scalar fields and gravity in the Einstein-Hilbert action, and have been broadly applied in cosmology. However, a plethora of variants of the ST theories are left unconstrained. To ameliorate the situation, I first found a way to recast the complicated field equations of certain ST theories into a neat formula, which enables one to extrapolate the dynamical properties of . I discovered that (i) the oscillatory frequency of is dramatically reduced as there exists strong NMC; (ii) NMC sometimes significantly deviates the dissipating behavior of the additional energy from matter. Both conclusions

point out that some proposals of the ST theories (e.g., Frank S. Accetta, Paul J. Steinhardt,

1991) are flawed at least in part of the whole parameter space. I subsequently verified my analytic results with numerical calculations and utilized the phenomenological properties of to constrain the impact of the ST theories on theCDM cosmology.

Several scholars have shown their interests in my research on the ST theories. In July 2016, I gave a poster presentation on my master’s research at “The 21st International Conference on General Relativity and Gravitation (GR21)” at Columbia University. Prof. XXX from X University was impressed by my work and invited me to Boston to give a presentation to his group. As a fledgling researcher, it was extremely encouraging. I further took the initiative and went to Canada to present my work to Prof. XXX at XX University. We discussed the possibility of constraining the cosmological scalar gravitational waves predicted by the ST theories. The interaction gave me many ideas to further develop my work. It also enhanced my ability to exchange ideas with other scientists, and gave me confidence that I do have some research acumen, which is indispensable for attacking intractable problems as a Ph.D. student.

Besides my academic achievements, I have participated in promoting equity in education for disadvantaged children and improving computer science education for high school students in Taiwan. Recognizing that many children living in rural areas do not have access to educational resources, I organized a volunteer group to teach Science, Arts and English to children in rural areas every weekend. Moreover, when I was doing my substitute military service, I designed a one-semester Astronomy quiz contest for an elementary school in a rural area. In both experiences, I stimulated students’ motivation for learning and received positive feedback from the local communities. Further, my friends and I initiated a project to translate the programming text “Computing without Computers” by Prof. Paul Curzon from Queen Mary University of London. We have further published the translation as an open educational resource and convened teachers from 30+ senior high schools to design lesson plans.

In October 2017, I visited XXX University and talked to several faculty members. I found daily events like the Astronomy Coffee very well-organized so the most important aspects of newly-published papers can be extracted in an efficient way. In a wonderful conversation with Prof. XXX, we discussed my opinion about the similarities between the Fuzzball paradigm and the KMY model of black-hole formation. After talking with more faculty members, I am convinced that XXX University provides a strong interface for research in cosmology, particle physics and astrophysics, which completely dovetails my research interests and experience. For instance, Prof. XXX’s work on both theoretical modeling and detection of solar neutrino interests me. Despite having long been observed, there are still many open questions about neutrinos’ properties and their role in cosmology. I can contribute my theoretical acuity and proficiency in neutrino experiment to XXX’s group. Furthermore, Prof. XXX is a theorist doing comprehensive research on topics ranging from dark energy, baryon acoustic oscillation to detector simulation of the Wide-Field Infrared Survey Telescope (WFIRST). This is also something I am keen to work on. Finally, I am interested in Prof. XXX’s project on heavy ion collisions, which is crucial to our understanding of the quark-gluon plasma in the early universe. I am also open-minded to research topics other than those listed above.

My long-term goal is to become a scientist who will make major breakthroughs in frontier research. Based on my academic experience and demonstrated passion for research, I believe that I am ready to tackle any challenges in the Ph.D. program at XXX University. I look forward to uncovering some deeper understanding of nature.