Summary of Undergraduate Research

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For the past year, I have been working under the supervision of Robert Mann with research focused on general relativity and cosmology. The two main projects I have undertaken thus far are as follows.

1 Lifshitz Solitons

One of the most important breakthroughs to emerge in theoretical physics over the past few decades has been the notion of holographic duality, which conjectures an equivalence between gravity theories on some spacetime and quantum field theories (without gravity) on its boundary. This idea has instigated fruitful lines of research into quantum gravity, quantum chromodynamics and, recently, condensed matter physics as well. There, it has enjoyed useful applicability to field theories that model quantum critical behaviour (e.g. strongly correlated electron systems), leading to a dual gravity theory known as Lifshitz gravity.

We investigated numerical solutions of this theory in (n+1) dimensions for solitons – objects with nonsingular spacetime geometries having Lifshitz asymptotic behaviour. In particular, last summer I took over this problem from Luisa Pegoraro (who had previously worked on it for her fourth-year physics research project) and, upon obtaining and verifying the final solutions using *Maple*, wrote the paper detailing our results which we published in December in Physical Review D.

2 Gravity Waves from Preheating in Matrix Inflation

Strongly supported by observations of the cosmic microwave background, the theory of inflation has come to be widely regarded as an inextricable part of the current paradigm in cosmology. It posits that, very early in its history, the Universe underwent a period of accelerated expansion leaving it flat, homogeneous and isotropic. Over the past three decades, a wide variety of different inflationary models have been proposed.

Lately, many of these have come to incorporate string theory in their construction, primarily in the form of open string and closed string models. A new string theory motivated approach, called matrix inflation, has recently been put forth by Amjad Ashoorioon (a former doctoral student of Prof. Mann) and collaborators, which is instead based on a mechanism that uses the internal matrix degrees of freedom from a stack of D-branes.

Since the end of last summer, we have been focusing on calculating observational consequences of matrix inflation that could distinguish it from other scenarios. In particular, I have been performing lattice simulations using a symplectic integrator to numerically obtain the power spectra of gravitational waves generated during the preheating phase of this model – that is, the period just following inflation where resonance thereof is expected to occur. It is then hoped that these spectra can be probed by future cosmic microwave background polarization experiments such as PLANCK, QUIET and CMBPOL.