From Dr. David Martin‘s Hubble fellowship applications:

unsuccessful:

Two planets and a star - discovering new populations of circumbinary planets and unveiling their distribution

The Kepler mission’s unparalleled combination of precision and timespan has confirmed the existence of planets orbiting two stars - circumbinary planets. Beyond an exotic niche subject, they are a unique tool in linking various fields of astrophysics. Their very existence is inherently associated to the binary, so advances are made in stellar physics. The observed distribution has yielded one of the strongest pieces of evidence for planetary disc migration. A surprisingly high abundance probes the ubiquity of planet formation. Orders of magnitude enhanced transit probabilities, even at long periods, make them excellent probes of the outer regions of solar systems and provide a pathway to characterising temperate atmospheres. There are presently 11 transiting circumbinary planets known. This small sample has already yielded intriguing insights, but our understanding is ultimately hampered by limited detection techniques and low-number statistics. Critically, there are two missing types of planets: planets on misaligned orbits and circumbinary Earths and super-Earths. As a Sagan fellow I will create and implement novel techniques to discover these systems or constrain their non-existence, first using archival Kepler data and then data from the upcoming TESS mission. Findings will be interpreted to make breakthroughs in multiple fields of astrophysics and produce the most comprehensive census of circumbinary planets known.

successful:

Solving super-Earth and mini-Neptune formation with circumbinary planets

The Kepler mission has yielded two particularly revolutionary results. First, there is a plentiful abundance of Earth and super-Earth sized exoplanets. Second, we have uncovered planets orbiting two stars - circumbinary planets - which possess advantageous observational properties and provide a unique probe of planet formation. However, these two results remain mutually exclusive; no circumbinary planet has been discovered smaller than 3 Earth radii, owing to the insensitivity of searches. As a Hubble fellow I conduct a two-part project. First, I will create and implement sophisticated automated techniques to discover roughly 50 circumbinary Earths and super-Earths transiting Kepler binaries, and potentially more in TESS. Many will have habitable orbits comparable to the inner Solar System. Enhanced circumbinary transit probabilities mean that the stars will be amongst the brightest known to host transiting planets, making these pristine candidates for atmospheric characterisation. I will tap this previously hidden gold mine in the Kepler data, and provide a necessary development for TESS. The second part of my fellowship will be to interpret this plethora of new results to develop revolutionary comparative planetary formation models, and leave a legacy of both targets and techniques for future instruments such as JWST and PLATO.