School of Physics and Astronomy

Proposed Project Title
First Year Summary

Patrick Sinclair
May 2018

Supervisor: Dr. Rosalind Allen

1 Project Outline

Antibiotic resistance is one of, if not the, most important issue in modern medicine. Despite the massive prevalence of antibiotic usage, with over 260,000,000 prescriptions being issued in the US alone each year, surprisingly little is known about the underlying pharmacodynamics, and what factors influence the emergence of resistance. This lack of understanding is becoming increasingly critical as our supply of viable antibiotics dwindles in comparison to the increasing number of resistant strains of bacteria. In 2014 there were over 480,000 cases of drug-resistant tuberculosis reported, with only half of those cases able to be successfully treated. Experts estimate that if current trends continue, the number of deaths caused by drug-resistant bacteria will number in the millions, making further research in the field vital.

Due to the enormity of this issue, it would be foolish to leave the responsibility of progress to just the biologists and chemists of the world. This project therefore aims to use stochastic computational modelling techniques to glean insight on how the presence of antibiotics influence bacterial colonies from a more physics based perspective. In particular, this project aims to investigate the impact of the application of antibiotics in the form of a gradient e.g., in the scenario of when drugs would be applied to a biofilm.

While these findings will obviously have important medical applications, they could also be of benefit in more industrial applications. In particular, impeding, or even halting the formation of biofilm formation on industrial shipping vessels. The shipping industry currently consumes an exorbitant amount of fuel. If it was a sovereign nation, it would be the 7^{th} largest producer of CO_2 on the planet and it's estimated that up to 45% of this fuel consumption in some cases is spent overcoming the additional drag caused by the formation of marine biofilms. Do

Progress so far

So far several investigations have been performed into the effects of antibiotic gradients on the evolution and proliferation of bacterial colonies. The first project undertaken was to replicate the results of a PRL paper co-authored by my supervisor, which modelled how the steepness of antibiotic gradients in conjunction with differing mutational pathways affected the time taken for resistance to emerge. This was primarily intended as a "warm-up" project, in order to gain familiarity with modelling these sorts of systems, and to build a foundation upon which further projects could be built. These simulations consisted of a simple 1D system

Following on from this, work on the next project began swiftly. This was

Outlook

Following a meeting with our industrial partners AkzoNobel, it was decided that work would continue for the meanwhile on the nascent multispecies model. They mentioned how designing the right combination and release schedule of antimicrobials in order to promote the emergence of favourable biofilm compositions was of particular interest to them, so they intend to send us data on various bacterial species and their corresponding growth rates/susceptibilities to several biocides such that they could be incorporated into the multispecies model in order to deliver more quantitative, rather than simple proof-of-concept results.

2 Critical Dependencies

If there are *critical dependencies* in your research work, detail them here, for example "*. . . my experimental work depend on the LHC being fixed. . .*" and what steps have been taken to deal(?) with them.

Also in this section outline any concerns about your progress, and in particular any aspect that you feel are impeding your progress.

3 Training and Courses

Course Attended in First Year

Name	Origin	Assessed	Hours
Intro to Soft Condensed Matter	SUPA	Yes	20
Physics of Biological Evolution	SUPA	Yes	10
Maths Primer	SUPA	Yes	6
Python	SUPA	Yes	8
Preparing for the first year review	Transkills	No	3

Courses to be Attended in 2018-2019

Name	Origin	Assessed
Computational principles to organize complexity	Summer school - INPHYNI	No
Advanced Data Analysis	SUPA	Yes
Introducing Biology to Physicists	SUPA	Yes
Hands-on Writing	Transkills	No

4 Teaching

Name	Semester	Hours
MfP1 Tutorials	1	40
Practical Physics (SciProg)	1	15
Physics 1B Labs	2	30

I intend to undertake a similar amount of teaching in my second year, but most likely in different courses.