Two-fluid Simulations with 2DX at UCLA (2012-2013). This work applied 2DX, a code capable of solving eigenvalue problems of any fluid model [1], to the ideal magnetohydrodynamic (MHD) fluid models associated with the edge region. Currently, this code has been successfully benchmarked against linear ideal MHD codes such as ELITE [2] for simple shifted circle geometry and ballooning dominated cases of peeling-ballooning (P-B) modes [3]. We extended this simple geometry study to peeling dominated cases before studying P-B modes in the more general case of strongly shaped two-fluid plasmas. Moreover, this code can be used to extend analysis of P-B modes across the separatrix to assess the effect of the scrape off layer model on stability. Ultimately, this code can also be benchmarked against non-ideal MHD models. The above work was presented at the 53rd and 54th APS DPP conferences.

Simulations of Turbulence Diagnostic for D-IIID at UCLA (2011). During the six weeks before the start of class at UCLA I modelled the propagation of 60GHz microwaves in fusion plasma using a Finite Difference Time Domain (FDTD) code developed by Dr. Shigeyuki Kubota. This code can be used to provide predictions for Doppler backscattering and reflectometry experiments that measure turbulence in D-IIID at General Atomics or the Large Plasma Device (LAPD) at UCLA [4]. After learning the IDL programming language I verified code by running it in a linear density gradient case and compared results with analytical calculations and publications on related simulations. Unfortunately, I didn't have time add several fluctuations along the beam path and a toroidal plasma velocity to simulate Doppler backscattering for a more realistic turbulence model of the edge region of a tokamak.

Bachelor of Science project at Imperial College London (2010/2011). The energy yield of fusion reactors is limited by plasma instabilities in the form of acoustic waves. The stability of these waves depends on the temperature gradient between the hot plasma core and the edge region [5]. Above a certain critical temperature gradient the acoustic waves become unstable. This limits the plasma's core temperature and hence fusion power. With the introduction of Hydrogen as a damping agent one could increase Landau damping and maintain plasma stability even at higher core temperatures. Thereby more intense fusion reactions could be sustained for longer periods of time, ultimately making fusion reactors more efficient. The flipside was that fusion of Hydrogen with Deuterium and Tritium does not produce net energy, i.e. doping also dilutes the fuel. This computational project quantified the effect of Hydrogen on critical temperature gradients and fusion power. The method had two stages. Firstly, I approximated the plasma dispersion function $Z(\zeta)$ with a fourth order Runge-Kutta method. Secondly, I used numerical methods on multi-ion dispersion relations (themselves functions of $Z(\zeta)$) to evaluate critical temperature gradients at which turbulence ensues at varying amounts of doping. The project concluded that even if Hydrogen makes up less than 15% of the fusion fuel it could increase core temperature by up to 17%, but the net magnetic confinement fusion power would decrease by 1-5%. Therefore doping increases the temperature gradient but also dilutes the fuel so that it fails to increase total power.

Undergraduate Research Opportunity (UROP) at Imperial College London (2010). My summer research project at Imperial's plasma group was in the field of Inertial Confinement Fusion. Under the supervision of Dr. Jeremy Chittenden I investigated how to reduce the Rayleigh-Taylor (R-T) instabilities, which jeopardize the homogeneity of the implosion of a cylindrical Aluminium liner onto a Deuterium fusion pellet [6]. I developed a computer model to compare the pressure variation of Aluminium at solid density and different temperatures in the four equation of state models MEDUSA [7], SESAME [8], PROPACEOS and MPQeos [9]. For analysis, samples of these models' data tables were plotted at logarithmic temperature intervals of 0.1 eV, 1.0 eV and 0.25eV, 2.5 eV. Analysis of the graphs and the models' inherent assumptions lead to the conclusion that MPQeos and MEDUSA produce the two most similar and accurate data sets. Therefore a marriage of both could create a pressure-density plot with the desired precision. The resulting equation of state model can be applied to evaluate shock wave propagation through the Aluminium liner. According to Slutz et al. this can be used to induce a precise shock onto the outside wall of the pre-heated liner so that the R-T instabilities are reduced. This can create a more homogenous implosion and possibly successful fusion of the Deuterium capsule within the liner.

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