Projects update, errata and corrections to the
MPhys Projects Trinity Term 2017

****** Updated Title and project description***

AO22 Modeling the atmospheric Quasi-Biennial Oscillation in the laboratory

The Quasi-Biennial Oscillation (QBO) is a cyclic reversal of the zonal winds in the middle and lower tropical stratosphere on a timescale of roughly two years. It dominates the climate of the tropical stratosphere, influencing the long range transport of momentum, heat and chemical constituents. It is also thought to play an important role in influencing the predictability of various features at higher latitudes and in the troposphere. Although the basic mechanisms that drive the QBO are reasonably well understood, arising from the nonlinear interaction of upward-propagating internal gravity and planetary waves (generated in the troposphere) with the zonal flow, its detailed variability is complex, chaotic and much less well understood. The atmosphere often surprises modelers with events such as the recently observed "stalling" of the QBO that their models failed to predict. The likely impact of future global climate change on the QBO is also quite controversial and uncertain.

In this project, we propose to study a number of mechanisms that might influence the behavior of the QBO using a laboratory analogue of the QBO, in which factors such as the wave forcing and other parameters can be closely controlled and varied. Internal waves are launched into a salt-stratified fluid in an annular channel by oscillating flexible membranes in the bottom of the tank. Each segment of the membrane can be separately controlled by computer to enable varying spectra of internal waves to be excited and for the amplitude of the waves to be varied in time (thereby emulating the seasonal cycle and other modulations). The response of the fluid to this forcing in the form of time varying velocity fields will then be measured by optical particle imaging techniques.

This project would involve setting up and running the experiment over a range of wave forcing profiles and frequencies, acquiring images of tracer particles and analyzing them to determine flow velocities as a function of time and space.

Skills required: Laboratory and some programming experience is desirable (e.g MATLAB, Python etc) though not essential.

Project may be carried out in laboratories in Engineering Science or AOPP (TBD).

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A&L23 Quantum Mode Selective Multiplexing

Light underpins all modern communication networks. Light is used to carry both classical information and more recently quantum information. The bandwidth of classical telecommunication networks using frequency multiplexing is reaching saturation and new multiplexing strategies are required to circumvent this to meet the demands of tomorrow. Furthermore, multiplexing is equally important in quantum networks because the underpinning building blocks of the network rely on probabilistic operations, and a multiplexing approach is necessary to scale up network size.

One exiting new approach is to utilise a new encoding approach using field orthogonal states for multiplexing both classical and quantum information. One such orthogonal basis is the temporal-frequency Hermite-Gaussian modes of the electromagnetic field. The challenge with these states is that one requires a time-non-stationary interaction to manipulate such states. To date, there have been demonstration experiments in field-mode orthogonal using parametric processes: the quantum pulse gate. However, these processes require significant experimental investment. Here at Oxford we are developing new approaches using off-the-shelf components.

The masters project would be a theory project that would investigate the performance of our device using the modelling of Heisenberg equations of motion using both theoretical and numerical approaches. The project will inform the upcoming experiments in the ultrafast quantum optics group.

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****** Updated Title and project description***

AO18 **Understanding Heat flow around the Lunar surface**

Thermal infrared measurements of airless bodies such as the Moon or asteroids can tell us a huge amount of information about their surfaces including their surface temperature, composition and texture. To obtain this information the measured thermal emission from the Moon or asteroid must be compared to a computer 3D thermal model of the surface. Typically, these models combine topography and compositional data using a combination of ray tracing techniques and solutions to the 1D thermal diffusion equation. This allows the model to calculate the expected radiance at the spacecraft.

These models generally do a good job at matching the measured radiance from the e.g. the lunar surface; however, in regions where the incidence angle of the incoming solar light is low and the dominate source of heat transfer is thermal re-radiation they have significant errors. Most 3D thermal models assume that light is scattered equally in all directions - a Lambertian surface, however it is believed that this assumption is incorrect particularly at high incidence angles.

We are in the early stages of development of our own 3D thermal model here at Oxford. Currently our model (written in MATLAB) is similar to previous 3D thermal models and we have obtained similar surface temperatures. However, we would like to extended our model to induce non-Lambertian scattering. This project will involve taking our existing model and adding a new module to include non-Lambertian scattering.

Skills: Coursework covering the fundamentals of radiative transfer e.g. from Atmos or Astro major options. For the computer-based elements programming experience be useful.

Reading: Paige et al. 2010 http://science.sciencemag.org/content/330/6003/479 , LRO Diviner instrument websitehttp://www.diviner.ucla.edu

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