Collaborative Research: the Physics of Thermal and Superfluid Turbulence

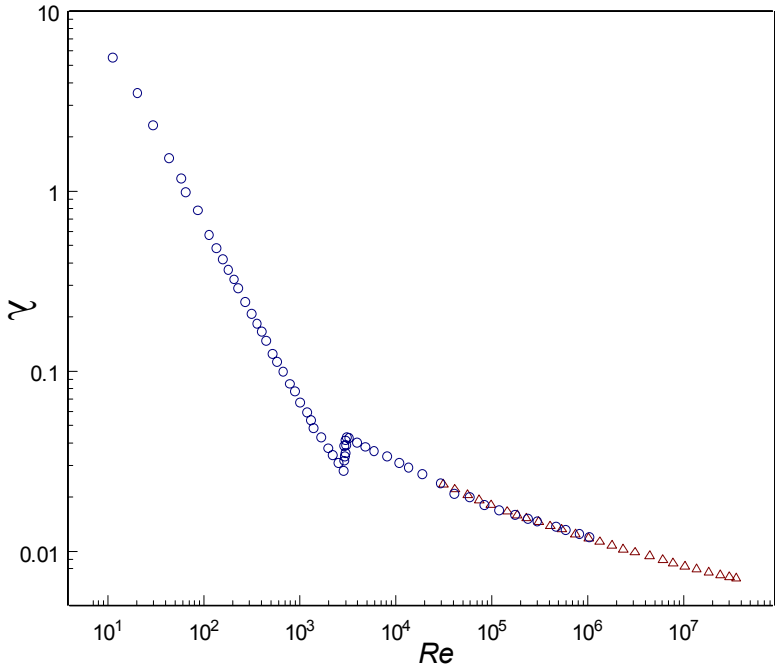
J. J. Niemela, K.R. Sreenivasan & R.J. Donnelly, DMR 0202554

•The Princeton and Oregon fluids research groups have recently published papers on the friction factor for flow of fluids through smooth pipes.

• The Oregon apparatus, manned in part by undergraduate and co-author Brian Julian, pushes liquid helium from a bellows through a 25 cm long stainless tube weighing about 1 ounce.

•The Princeton "superpipe" pushes highly compressed air around a closed loop of pipe 34 m long, weighing 35 tons.

•We recently combined the data from the two labs. Plotting the dimensionless friction factor λ as a function of Reynolds number (Velocity x pipe diameter/viscosity) should scale the two



sets of data, which indeed is the case, extending our knowledge of the friction factor from Reynolds number 10 to 36,000,000. The triangles are from Princeton and the circles from Oregon. Where the data overlap the two sets differ by only 1.7%. This is a stunning illustration of the power of dimensional analysis.

The friction factor for pipeflow allows a scientist or engineer to calculate the pressure drop for almost any fluid through almost any size of pipe. Among other things it tells the designer what kind of pump will likely be needed for the job. This diagram will appear shortly in the Journal of Fluid Mechanics. It has already been incorporated in a standard engineering textbook (Incompressible flow by Ronald Panton) and will likely appear in every book discussing fluid motion: this includes basic subjects like physics, and mechanical, aerospace and chemical engineering as well.

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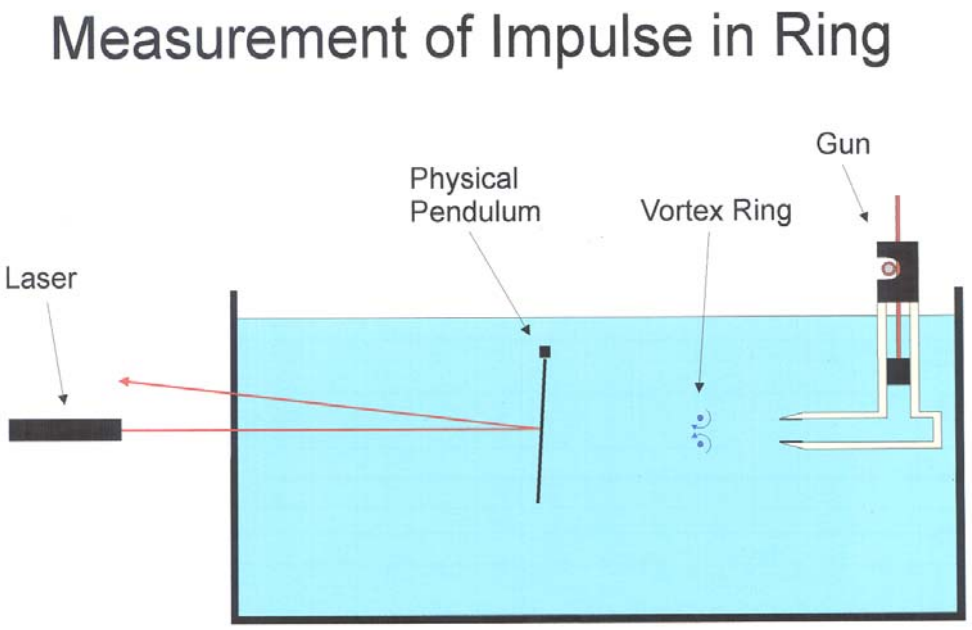
•Conflicting papers in the low temperature physics literature claim a vortex ring does/does not transfer momentum (formally "impulse") to a wall it hits. Undergraduate Ian Sullivan (now at CalTech getting a PhD) set out to resolve this conflict using a physical pendulum in water.

• After suitable calibration Ian found that the impulse collected by the pendulum is almost exactly equal to the momentum of the water pushed from the gun.

•This means the theoretical background of these papers needs to be revisited.



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Outreach

DMR has supported Low Temperature Physics since its inception. LTP is a field which has garnered 27 Nobel Prizes, but is virtually unknown to the public.

Russell Donnelly is proposing a two hour prime time PBS special called "Absolute Zero and the Conquest of Cold" after the book of the same title by Tom Shachtman.

A third hour is planned for high school and college showing, which is at a more technical level than the two hour show

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The producers are Windfall Films in London and Meridian Productions in DC. Windfall has already won two Emmys for science productions, and many other awards

Total cost of AbZ is estimated at $4.2M. NSF has awarded $1,756,702 (ESI-0307939) and the Sloan Foundation $550,000. The remainder is being sought from corporations and foundations.

The presenting station is TPT in Minneapolis, who will also do the website. It is hard to estimate viewership but it should be in the tens of millions