Sir G I Taylor As I Remember

My memory of Sir G I Taylor goes back to the year 1970 when I was at Caltech. At that time I was a PhD student of P G Saffman who had earlier worked with G I Taylor at Cambridge. It was announced that Taylor would be visiting Caltech to deliver a seminar on low Reynolds number flows at the Guggenheim Aeronautical Laboratories (GALCIT) I was particularly excited about the seminar as I had earlier done some work on the effect of compressibility at low Reynolds number as a part of my PhD dissertation. I had heard of Taylor's work at Cambridge. Taylor had the reputation of being a scientist with extraordinary physical insight into problems of fluid mechanics. During the war, he had correctly calculated the yield (total energy release) of the first American atomic explosion based only on a time tagged sequence of photographs of the explosion released by US Government for publicity purposes and freely available at that time. He used dimensional arguments in arriving at the expression for the temporal development of the fireball and by comparing it with estimates from the photographs, arrived at the correct value for the yield of the explosion – a figure which was closely guarded secret at that time.Taylor had also done pioneering research in low Reynolds number flows, flow instabilities, turbulence, and flows in rotating systems. He was a good sailor and invented and patented a novel anchor which was much more effective for its weight than earlier types.

I was looking forward to the seminar with much excitement. Though the event is almost 34 years old now, I still remember some of the main elements of the talk. Fluid flows at low Reynolds numbers constitute a domain where viscous forces dominate. Our everyday experience, being largely in the domain of large Reynolds numbers with inertia forces dominating, does not provide insight into this domain. For example, micro organisms operating in this domain have to achieve mobility by using viscous forces for propulsion and the principles involved here are quite different from the ones used at large Reynolds numbers as in the case of airplanes.

G I Taylor first considered the motion of a thin circular rod falling under gravity in a highly viscous fluid. If the rod is released in the fluid with the axis of the rod vertical, the rod sinks vertically such that, at the steady descent speed, the resultant of viscous forces (drag) on the cylindrical surface balances the weight of the rod. The flow is axially symmetric in this case. On the other hand, if the axis of the rod is horizontal at the time of release, the flow is two dimensional in a plane perpendicular to the axis of the rod. However, the resultant of viscous forces on the cylindrical surface still constitutes a drag which turns out to be much larger than the value in the previous case for a given sink speed. Thus the rod, while staying horizontal, sinks more slowly as compared to the earlier case. In both the cases, the motion of the rod is vertical. A more interesting case arises if the rod is released in an inclined position to the vertical. The rod while maintaining its inclined attitude, descends at an angle to the vertical – i.e. it glides. This is so because the resultant viscous force which is vertical and balances the weight of the rod and the motion of the rod which is inclined to the vertical, are in different directions (This is due to the rod moving relatively faster along its axis-the direction of lower drag). Expressed differently, when the rod moves along a direction inclined to its axis, there is a component of viscous force at right angles to the direction of its motion – it produces lift. The existence of this force component is vital for propulsion in viscous flows.

Propulsion using the above phenomenon is illustrated easily. If a circular rod is wound into a helical spring and is rotated about its axis while immersed in a viscous fluid, there will arise a propulsive force along the axis of the spring. Taylor illustrated this using an electric motor-driven model in a tank of highly viscous fluid. Using the same principle, many microorganisms (and not so microorganisms like snakes) swim by moving their wavy cylindrical bodies in a periodic manner at right angles to the direction of motion. Taylor showed a film clip of spermatozoa, which essentially have spherical heads followed by cylindrical tails, making progress towards an egg cell by lashing their bent tails laterally. Taylor remarked that the importance of this phenomenon to life on earth should be obvious.

What was particularly interesting about the talk was the importance given to the physics of the problem while not avoiding the mathematical modelling. This is in marked contrast to many seminars I have attended wherein the technical and mathematical aspects are presented in great detail while little attention is given to their interpretation. Perhaps there is a lesson which academic researchers can learn from Taylor's style of presentation.

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