Flying saucers

For most of us frisbees are just a bit of fun, so why is planetary scientist **Ralph Lorenz** taking them so seriously?

THROW a frisbee just right and it can skim straight for dozens of metres, arc across the sky, or zoom up before gliding gently to the ground. Misjudge the flick of your wrist and the spinning plastic disc will wobble precariously before flipping over and falling to earth. Why is it so easy to go wrong?

Embarrassingly, no one really knows why it is so hard to throw a frisbee straight, and why such a simple piece of plastic can fly in so many different ways. It's a problem that also bedevils our understanding of other flying objects, including space probes hurtling through the atmospheres of alien planets. Which is why, as part of my work as a planetary scientist, I have been out in the fresh air, studying the dynamics of frisbee flight.

Frisbees in one form or other have been around for more than 130 years. The name comes from William Frisbie, a 19th-century Connecticut baker whose pie tins, turned upside down, were renowned fliers.

What makes frisbees such good fliers is their shape: a flat disc with a deep, downward-curving lip all round. As the frisbee flies forwards, the flow of air around the lip makes it behave as a short, stubby wing. Air passing over the top of the disc moves faster than the air below it, and this lowers the pressure on the top of the disc, creating the aerodynamic lift needed to keep the disc afloat.

But there are complications. The front of the disc experiences more lift than the back, and this tends to make a frisbee's flight unstable. Unlike aeroplanes, which have a tail to keep them steady, frisbees have no extra surfaces to control the uneven distribution of forces across the disc, so they tend to flip. But they do something aircraft can't do: they spin around their vertical axis. It only takes a minute or two playing with a frisbee to realise that spin is the key to a successful throw. It's the same principle that keeps gyroscopes and spinning tops upright: nudge a rotating gyroscope and you find that it doesn't fall to the ground; only its spin axis is knocked off-course. In the same way, when a frisbee is spinning, the uneven lift causes it to veer off to one side rather than flip completely.

Another plus for the frisbee is the rim, because most of a frisbee's mass is concentrated there, making it more stable than a flat spinning plate. Because the rim is quite thick, though, a frisbee experiences more aerodynamic drag than a flat disc flying through the air. Aeronautical engineers tend to view drag as a bad thing, because it slows aircraft down, but in a frisbee the drag-producing rim helps to distribute the forces more evenly around the surface. The air flowing underneath the disc tends to get caught under the rim at the back the disc. This increases the lift at the rear of the frisbee somewhat, limiting its tendency to veer or flip. Finally, frisbees have grooves on the top surface that help to reduce the drag force that slows a smooth disc down.

It turns out that the lift and drag forces on a frisbee depend on a parameter called the angle of attack – its back-to-front tilt relative to its direction of flight (see Diagram). For a frisbee to fly straight, and without flipping, the optimum angle of attack is 10 degrees.

But these basic features of frisbee flight do

FLIGHT OF A FRISBEE

The forces on a frisbee tend to make it flip – unless it's spinning