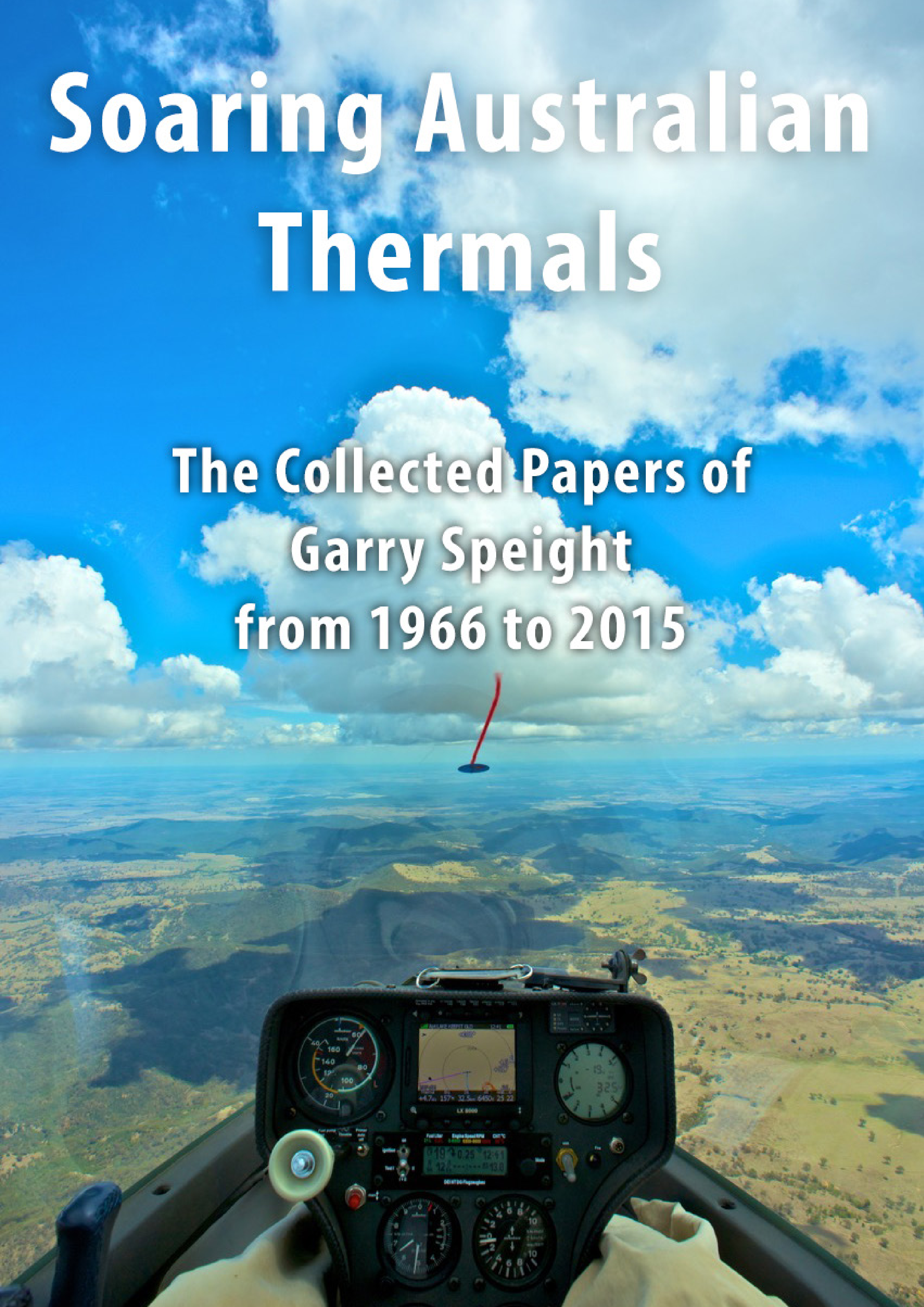
Soaring Australian Thermals

The Collected Papers of Garry Speight from 1966 to 2015



Thermals That Rotate, Part 3

By Garry Speight

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Many thermals rotate, and they may be the strongest of the day. You can soar better if you learn to work them. Circling against the rotation is a dream; circling with it, a nightmare!

Part 3: How the glider behaves

Symptoms Of Thermal Rotation

In Part 1 I argued that there are a lot of rotating thermals about, and I listed things I had noticed when flying in them:

Flying with the rotation

- The average rate of climb was much lower than in the strongest surges.
- The air was very rough.
- I had to hold the nose of the glider low to keep good control.
- Keeping the nose steady on the horizon did not give a steady airspeed.
- The core of the thermal seemed to be small; I could stay in it only with a very steep angle of bank, if at all.
- Once found, the core was easy to lose, and seemed to move around.

Flying against the rotation

- The average rate of climb was almost as high as in the strongest surges.
- The air was very smooth.
- I could hold the nose of the glider high while keeping good control.
- The airspeed stayed steady and the nose of the glider stayed at the right height without my moving the stick.
- The core of the thermal seemed to be large; I could easily stay in it with a moderate angle of bank.
- The core seemed to stay in one place; centring called for so few control movements, the glider almost flew itself.

Each of these things follows from the features of rotating thermals I described in Part 2.

Why The Glider Behaves As It Does

The size of the circle

Some of the effects of flying with the wind in a rotating thermal happen simply because the circle at a chosen bank angle is so large.

As shown by the larger circle in Figure 3.1, the glider may stay outside the core, where there is much weaker lift and rough air (shown by hooked arrows). To keep control the pilot must not stall

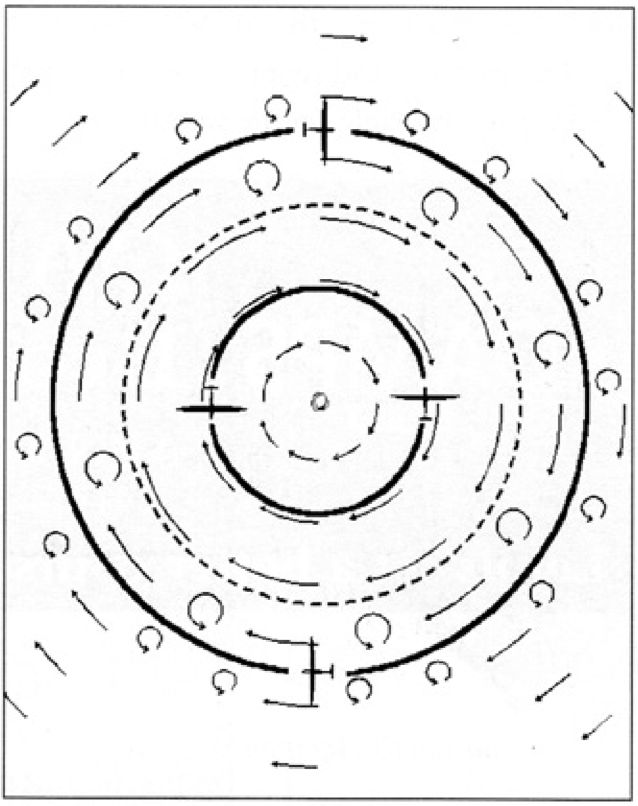

Fig 3.1. The wind pattern in a rotating thermal (shown by arrows), and its effect on a glider flying with and against the rotation. The dashed line is the edge of the thermal core

in tail-wind gusts. This calls for a higher airspeed, making the circle even larger. The rough air also causes more drag on the wing at low speed. (See Note 1.) The pilot must lower the nose of the glider and fly faster.

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When flying against the wind, shown by the smaller circle in Figure 3.1, the glider is likely to be within the smooth air of the thermal core all the time. The pilot can raise the nose and fly slowly, getting the best out of the glider.

The size of the glider's circle explains differences in rate of climb, air roughness, and the height of the nose of the glider.

As for the thermal core seeming to be bigger or smaller, it is not the core that is different, but the gliders circle. The pilot can't know how big the circle is.

Stable and unstable orbits

Something else makes the thermal change from well-behaved to spiteful when the pilot circles the wrong way.

The pattern of winds in a rotating thermal affects the path of the glider, to make its orbits either stable or unstable.

- Stable orbits are circles centred on the thermal axis. The glider flies at a steady speed.
- Unstable orbits are oval, strangely-shaped curves that swing towards and away from the thermal axis. The glider flies at an unsteady speed.

In a word, the glider is very easy to control when flown against the thermal rotation, because its orbits become stable. It is very hard to control when flown with the rotation, because its orbits become unstable.

If flying against the rotation within the core of the thermal (see Figure 3.2), the pilot meets a headwind that gets stronger away from the thermal axis. In this case, the rotating thermal tends to make the glider fly in a circle centred on the axis. Suppose the glider is moving slightly away from the axis, as shown on the left in Figure 3.2. It meets a stronger headwind, which gives a higher airspeed. The pilot, to slow down, puts a little back pressure on the stick. This moves the glider back in towards the correct circle. In the same way, any chance movement towards the thermal axis (on the right in Figure 3.2) will give a lower airspeed. The pilot, to speed up, puts forward pressure on the stick. Again, this will return the glider towards the correct circle. (See Note 2)

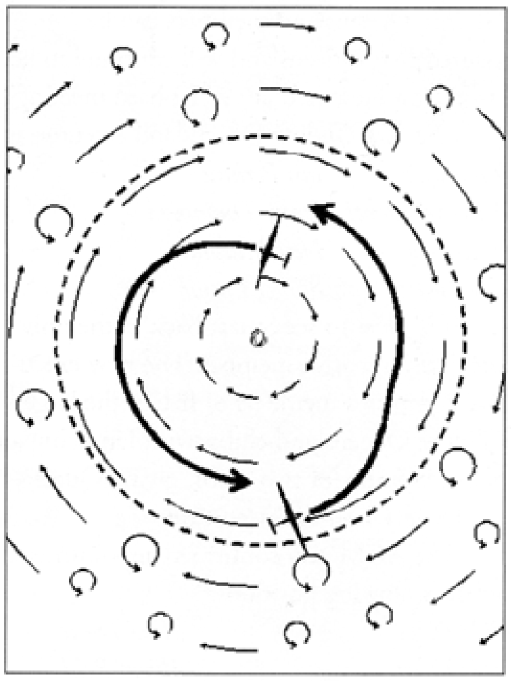

Fig 3.2. Self-centring while flying against the rotation in the core of a thermal

It may happen that, while circling against the thermal rotation, the glider is flying outside the thermal core (see Figure 3.3). Perhaps the pilot is using too little bank, or has not yet found the core. Outside the core the headwind gets weaker away from the axis. Now, if the glider is moving slightly away from the thermal axis (Figure 3.3), it

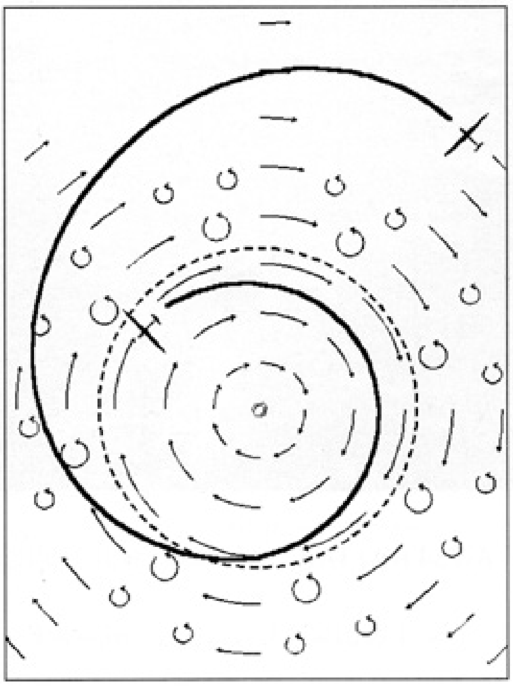

Fig 3.3. A thermal flown against the rotation. An unstable orbit outside the core soon becomes a small stable orbit inside the core

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meets a weaker headwind. The airspeed falls, the pilot eases the stick forward, and the glider moves even further away from the thermal axis. This orbit is unstable. Happily, on the other side of the same unstable orbit (on the left), the glider moves towards the thermal axis. Here it meets a stronger headwind. It will gain airspeed, and the pilot, pulling the stick back, will bring it even closer to the thermal axis. It is likely to enter the thermal core. There, the glider will fly at a constant, small radius, and stay inside the core. After only one unstable orbit, the orbits have become stable.

A pilot flying in a tailwind by circling with the thermal rotation may have a wild ride! Because the ground speed is high, making the circle large, the glider will fly mainly in the rough air outside the thermal core. At first the glider's circle, in a tailwind that gets less away from the thermal axis, tends to centre on the axis. This happens in the same way that its circle inside the core tends to centre on the axis when turning against the rotation. These first orbits, flown with the rotation but outside the core, are stable. By chance, every now and then, the glider may enter the strong smooth lift of the core. The pilot will try hard to make the circle smaller, to spend more time in the core.

The orbit is unstable in the core (see Figure 3.4). The glider will not keep flying at the same radius from the thermal axis. The gliders path curves towards the thermal axis, slowly at first. As the tailwind gets less, the airspeed rises and the pilot pulls the nose up. With ground speed falling, the glider is quickly sucked in close to the axis. As it starts to move away again, with the tailwind getting stronger, the glider is thrown right out of the core. By that time it will have a high ground speed, or a low airspeed, or both. On each pass through the core, the pilot has a choice: try to hold the airspeed steady by raising and lowering the nose, or try to hold the nose steady on the horizon and let the airspeed vary. Neither choice will do much good. The pilot is barely in control.

The glider may pass through the core in this way many times without ever getting a full circle in it (Figure 3.5). The radius of turn is too big.

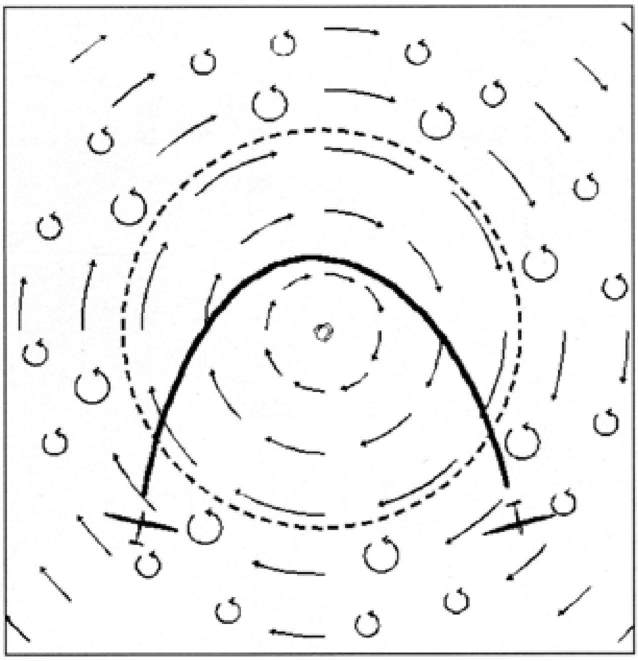

Fig 3.4. An unstable pass through the core of a thermal flown with the rotation

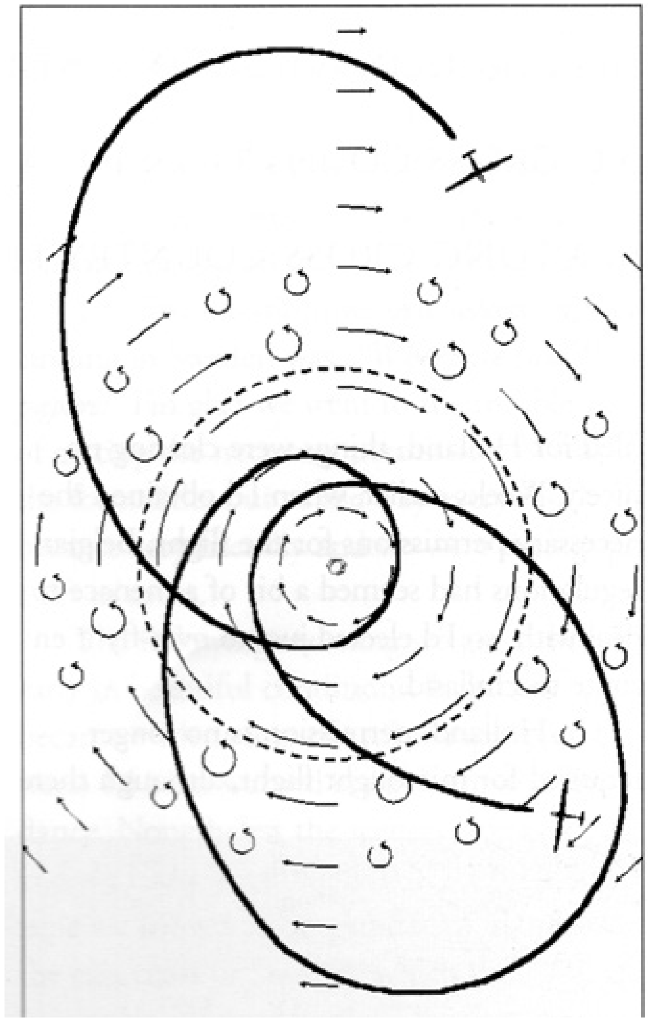

Fig 3.5. Unstable orbits in and out of the core of a thermal flown with the rotation

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Thus, the way the pattern of rotating winds changes the path of the glider explains the remaining effects of thermal rotation. Flying with the rotation, it is very hard to control the airspeed, and a tiny thermal core seems to jump to a different place on each orbit. Flying against the rotation, the airspeed is steady, and the glider stays in the core by itself.

In a few words:

A thermal that rotates like a very weak tornado will make a glider behave in the ways I have described. Other pilots have also noticed the glider behaving in these ways. The strongest and most perfecdy circular thermals may often rotate like that. They will give a great rate of climb, and be very easy to use, but only when you circle against the rotation!

What To Do About It

The figures in this part of my article show the glider at the mercy of rotating thermals. The pilot keeps circling in the usual way, blind to what is going on. If circling against the rotation, the pilot thinks the thermal is big and smooth. If circling with the rotation, nothing goes right.

In Part 4 I will show how to use rotating thermals.

Technical Notes

1. Gerhard Waibel reported that glider pilots find lower glider performance in turbulent thermals. His report stimulated a paper by Fabio P. Bertoletti (2001): "Effect of atmospheric turbulence on a laminar boundary layer" (Technical Soaring 25(2), pp154-159). Bertoletti says that turbulence of a few cycles per second (felt as "bumps") causes early transition from laminar to turbulent flow within the boundary layer on the glider wing. Such turbulence makes "streaks" run back along the chord. In one streak, the boundary layer is thinner and faster: in the next it is thicker and slower.

2. I am not sure whether a glider, by its design, will self-centre in such a case even without pilot action.

A Lake Keepit April afternoon sky