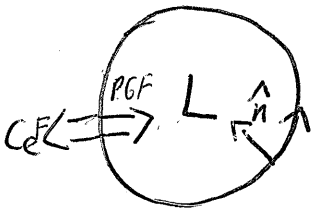
Cyclostrophic Flow

In small-scale systems the radius of rotation may be of the order of hundreds of feet as compared with the usual systems portrayed on weather maps which may have radii in hundreds of miles. For this reason, the centrifugal term $|\vec{V}|^2/R$ becomes much larger in small systems. Because the Coriolis force is proportional to $|\vec{V}|$, it is negligible compared to the centrifugal force even at fast speeds.

Under such conditions, (1b) becomes

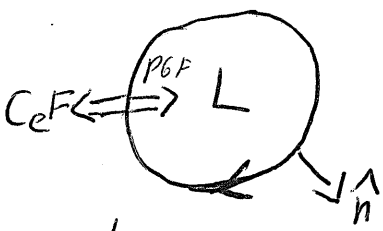
$$(11) \qquad \frac{|\vec{V}|^2}{R} = -\frac{\partial \Phi}{\partial n} \qquad \text{or} \qquad |\vec{V}| = \pm\sqrt{R\left(-\frac{\partial \Phi}{\partial n}\right)}$$

where the pressure gradient balances the centrifugal term. The flow will always be around a low-pressure center, and since the Coriolis effect is negligible, the sense of rotation may be either cyclonic or anticyclonic. See Fig 3.4. In one case, for cyclonic flow ($R>0$)



$R>0, \quad \frac{\partial \Phi}{\partial n} < 0$

while for anticyclonic flow



$R<0, \quad \frac{\partial \Phi}{\partial n} > 0$

Since $|\vec{V}|$ must be real,
no cyclostrophic solution exists for a high.

Small-scale systems obey cyclostrophic balance. These include dust devils and waterspouts. Both low pressure systems form from very buoyant plumes of ascending air, then acquire a spin which may be either cyclonic or anticyclonic.

Tornadoes also obey cyclostrophic balance. Tornadoes form at the intersections of strong updrafts and downdrafts, and due to the environment of "supercells," tend to spin cyclonic. However, anticyclonic tornadoes have been observed. It is a misconception that tornadoes spin due to the Coriolis force.

Cyclostrophic balance is valid provided that the centrifugal force is much stronger than the Coriolis force at any scale. Cyclostrophic balance is valid for large Rossby numbers ($R_o = \frac{|\vec{V}|}{|fR|}$). At the inner core of hurricanes where the centrifugal force is large, cyclostrophic balance is valid.

Hurricanes always spin cyclonic because they need the Coriolis force to form. However, once a hurricane matures, the Coriolis force becomes small near the center. Rossby numbers near a hurricane's center may be 100 or more, which means the pressure gradient is balanced by the centrifugal force in the eyewall region.