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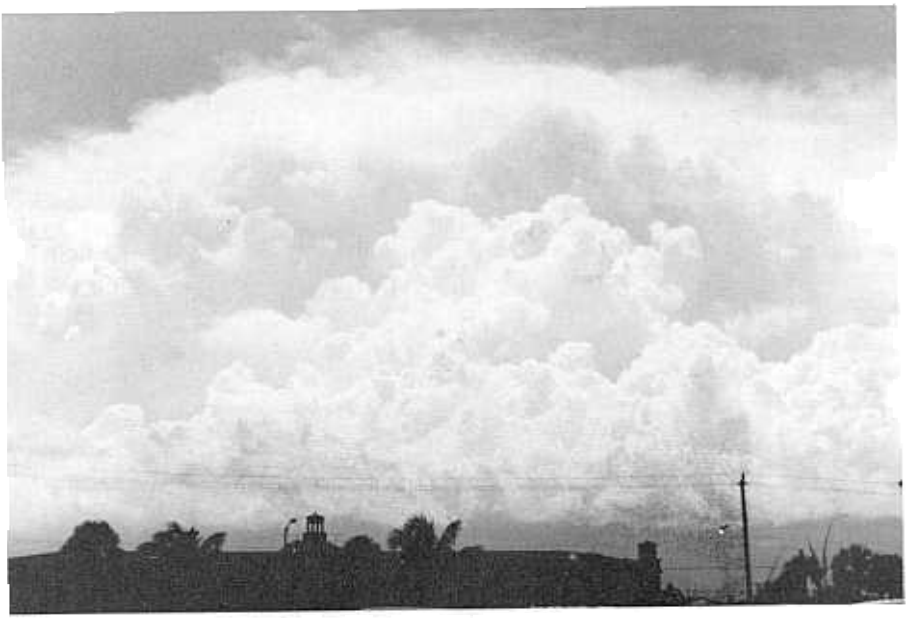

Photograph by T. J. Brown

Cumulus congestus and cumulonimbus over the Everglades of Florida seen from Fort Lauderdale at 1515 local time 8 July 1981. Florida was in a hot humid south-easterly airstream, following the passage of a warm front north-westwards from the Caribbean. Surface temperatures reached 37°C inland over Florida and cumulonimbus developed widely. Heavy hail and funnel clouds were reported in severe thunderstorms during the afternoon

THE HEILIGENSCHEIN

The 'heiligenschein' is a bright aureole that is sometimes seen round the shadow of an observer's head on grass, on other vegetation or on rough surfaces. Three mechanisms can contribute to its brightness: the shadow effect, the glory effect and the magnifying-glass effect.

The shadow effect can be summarised thus. If an observer looks at the grass near the shadow of his head he will not see the shadow of grass blades on other grass blades, for his direction of vision is parallel to the incident sunlight. If, however, he looks at

the grass in a place some distance from his shadow, then part of the grass will look darker, because of the shadows of other grass blades; therefore the brightness will be less there than that near the shadow of his head. In some cases the shadow effect is the only cause of the heiligenschein (dry heiligenschein), e.g. on dry grass or on the ground seen from an aircraft (Minnaert 1954, Larmore and Hall 1971). Incidentally it is also the shadow effect which causes the full moon to be nine times as bright as the first or last quarter.

The brightness of the heiligenschein is much enhanced when there are dewdrops on the grass or other vegetation (dew heiligenschein). In dew droplets that are too big to be spherical, internal reflections may occur which redirect the light in the direction of the source and therefore, if the observer is looking at the shadow of his head, towards the observer's eye. This enhanced brightness is called the glory effect, since the ray-path in this case is rather similar to the ray-path of the glory.

For the glory effect to occur the refractive index must be greater than $\sqrt{2}$ for spherical droplets (Tricker 1970). The refractive index (μ) of water ($\mu = 1{\cdot}33$) is therefore too small to cause the effect. Tiny spherical dewdrops do, however, contribute to the brightness of the heiligenschein in that they give rise to the magnifying-glass effect. This in fact is the most effective of the three mechanisms mentioned. It occurs because the incident sunlight is focussed on a droplet-covered surface (the blade of grass or other vegetation) causing a bright spot; the observer sees the light via the droplet which acts as a magnifying glass, and redirects the light to the source and to the observer's eye. For this effect to occur the optimum distance d between the back of the droplet and the reflecting surface in the case of water ($\mu = 1{\cdot}33$) is equal to the droplet's radius r; in the case of glass ($\mu = 1{\cdot}5$) $d = r/2$ (e.g. the Campbell-Stokes sunshine recorder) (Mulder 1976). The magnifying-glass effect certainly makes the greatest contribution to the heiligenschein of Fig. 1, where there are many small dew-droplets on the grass.

Fig. 1 Heiligenschein seen on dew-covered grass

The heiligenschein caused by the magnifying glass effect can be observed on other, quite different occasions, too. The photograph of Fig. 2 was taken on the beach and shows a very shallow layer of rippling water. The ripples act as a converging lens in the same way as the dew-droplets; the reflecting surface in this case is the sandy beach.

The magnifying-glass effect is so effective that it is also used commercially. The

retroreflective materials of traffic-signs, number-plates of cars etc are technical applications of the heiligenschein. Although glass spheres are used and the glory effect therefore occurs, each glass sphere is given its own reflecting surface so that the

Fig. 2 Heiligenschein on the beach

brightness is enhanced many times (owing to the magnifying glass effect). Just as the grass near the shadow of the observers head was brighter than the grass further away (Fig. 1), so the number-plate of the car near the observer's head in Fig. 3 is much brighter than the other number-plate.

Therefore the heiligenschein is not only a grass halo, or a halo in the ricefield, as the Japanese say (Corliss 1977), but it is also a moon halo, a beach halo, and a

Fig. 3 Heiligenschein seen on the number-plate of a car. The number-plate near the shadow of the photographer's head is brighter than the number-plate further away

number-plate halo. It may well occur in other situations when the right conditions prevail.

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ADDENDUM

DISTANT READING THERMOMETER

In his description of how to make up this thermometer, Hood, (*Weather*, **36**(7) pp. 209–213) the author omitted to state that the zero-adjusting push switch has an additional function: with the thermometer set up for normal use, and switched ON, if the button is pressed the meter pointer moves to approximately mid-scale; thus considerably extending the range downwards. All that is needed is to calibrate an additional scale parallel to the main scale.