

## Atmospheric physics

# A new dawn for aurora

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A new type of aurora has been observed. Although similar in shape to conventional aurora, it lacks their intensity and dynamics, instead rotating quietly with the Earth.

'Aurora' is the term given to the glow created when energetic particles from space strike Earth's upper atmosphere, or ionosphere. Aurora — also known as the Northern and Southern Lights (*aurora borealis* and *aurora australis*, respectively) — usually occur within rings around the magnetic poles. Each ring is up to about 3,500 km in diameter and a few hundred kilometres deep. This 'auroral oval' contains discrete aurora, which form curtain or ray shapes that are often easily visible with the naked eye (Fig. 1), and diffuse aurora, which are fainter and lack sharp spatial boundaries. In *Geophysical Research Letters*, Kubota *et al.*<sup>1</sup> report new auroral observations that fit neither category and lie several degrees below the auroral oval. Most intriguingly, the sub-oval aurora appears to co-rotate with the Earth. These observations suggest that an old idea<sup>2</sup> about how aurora get their shapes may yet prove to be true.

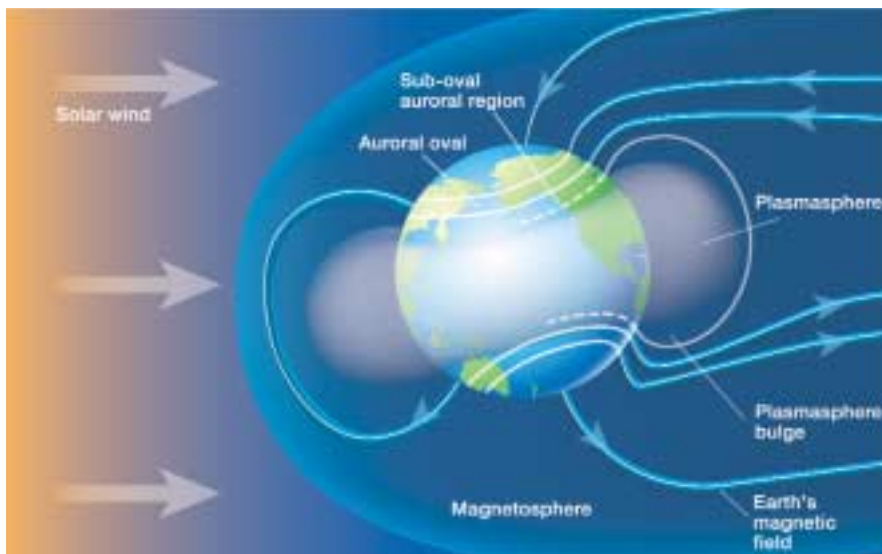
Kubota *et al.*<sup>1</sup> used high sensitivity all-sky cameras at Poker Flat, 30 miles north of Fairbanks, Alaska. Much of the time, the solar wind drives a flow of ionized particles, or plas-

ma, around the Earth; as a result, electric current flows from space into the upper atmosphere, creating moderate or high geomagnetic activity and bright aurora. Under such conditions, the Poker Flat observing station lies within the auroral oval, and fulfils its intended function of studying discrete and diffuse auroral forms. When geomagnetic conditions are quiet, however, the position of the auroral oval lies polewards of Poker Flat, and no aurora are expected at this site. Yet under these conditions, Kubota *et al.* discovered faint auroral structures, with a distinctly different phenomenology (Fig. 1). These sub-oval aurora have the ribbon-like appearance typical of discrete aurora within the auroral oval. But they also have the quiescence, persistence and low intensity that are more typical of diffuse aurora. Data from an overflying US Air Force satellite showed no acceleration of the electrons impacting on the atmosphere — as is the case for conventional discrete aurora.

The sub-oval aurora also move with the Earth, at about 70% of its velocity, drifting at  $140 \text{ km s}^{-1}$  in the direction of Earth's spin. This is a surprise, and a suggestive one. Auroras tend to be positioned such that an observ-



Figure 1 Northern lights. Bands of green light across the Alaskan sky form the *aurora borealis*, usually seen inside the auroral oval that surrounds the Earth's magnetic pole. But Kubota *et al.*<sup>1</sup> have detected a new type of aurora (inset) that occurs at latitudes below the auroral oval and is phenomenologically quite different.



**Figure 2** The Earth's magnetic environment. Our planet's magnetic field forms a protective bubble (the magnetosphere) that excludes most of the solar wind. The plasmasphere — a region of cold plasma — fills near-Earth space, and bulges outwards over the part of the planet that is at dusk. Energetic particles from space striking the atmosphere create aurora, which are generally contained within the auroral ovals around the planet's magnetic poles. But Kubota *et al.*<sup>1</sup> have observed a new type of aurora over Alaska, at lower latitude than the auroral oval. The new sub-oval aurora are quite different to those usually observed in the auroral oval, and may be connected to the impingement of the plasmasphere's bulging boundary on the atmosphere below.

er on Earth sees auroral patterns apparently drifting westwards, as Earth's spin actually rotates him eastwards. Kubota and colleagues' faint co-rotating aurora must therefore be more closely linked to the near-Earth region than are previously known aurora.

A few earlier, related observations do exist. Photographs from the ISIS-2 satellite<sup>3</sup> showed instances of 'detached aurora', lying below the main auroral oval. Only one image of these aurora was available for each orbit of the satellite, and little could be learned from them. However, there has been much discussion<sup>4,5</sup> in the past few years of potentially related phenomena, such as sub-auroral ion drifts and sub-auroral polarization electric fields. Interest in these phenomena has been sparked by clear evidence<sup>6</sup> that the upper atmosphere at middle latitudes has a surprisingly strong connection to activity in the auroral oval and to the solar wind. Kubota and colleagues' work seems to show that these are not, in fact, sub-auroral phenomena, despite lying below the established oval of discrete and diffuse aurora. Whether they are related in some way to the new sub-oval aurora is not yet clear.

More than two decades ago, Carl McIlwain (co-discoverer of the Van Allen radiation belts that surround Earth, with James Van Allen) proposed an explanation<sup>2</sup> for why some aurora appear latitudinally narrow but longitudinally elongated. Earth is surrounded by a plasmasphere — a co-rotating sphere of cold plasma, which flows up from the ionosphere (Fig. 2). Over the sector of Earth experiencing dusk, the plasmasphere often bulges outwards, in

response to the Earth's rotation and to the electric fields induced by the solar wind. McIlwain thought that the aurora might be shaped by the protrusion, following Earth's magnetic-field lines, of the swelling boundary of the cold plasma into the ionosphere below. But his idea proved not to fit the aurora observed within the auroral oval — diffuse aurora are too spatially unstructured to match a boundary, and discrete aurora have rapid dynamic motions resulting from lower-altitude coupling of the ionosphere and the magnetosphere.

The quiescent, discrete, elongated aurora discovered by Kubota *et al.*<sup>1</sup>, however, fit the bill. Their near co-rotation with the Earth also supports McIlwain's model, which Kubota *et al.* seem to have independently resurrected. If these findings and associations are confirmed, they could help to explain the unexpectedly strong connection between the solar wind, the aurora and the composition and electron density of Earth's upper atmosphere, even at latitudes that are nominally below the auroral oval. ■

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