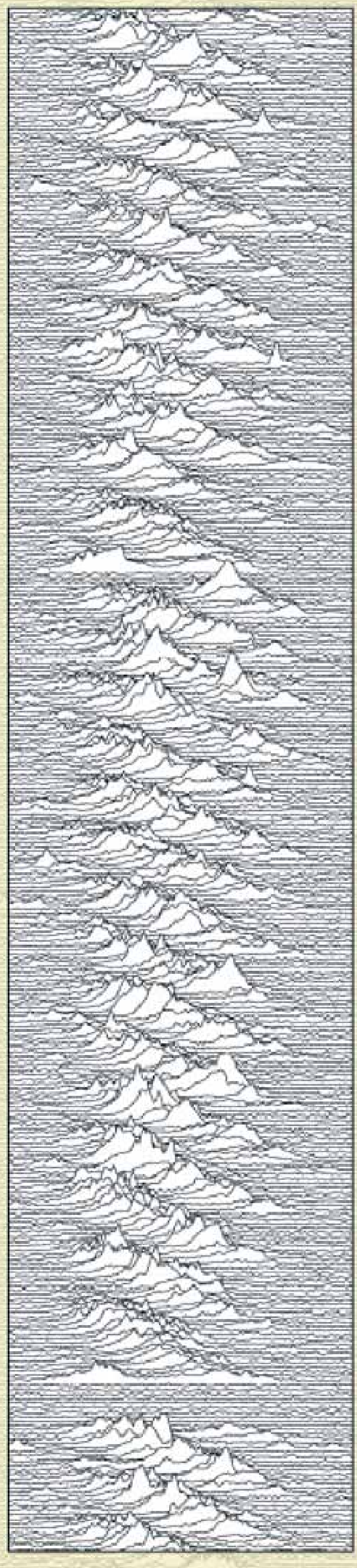

subpulse drift in slow and fast pulsars

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for more background, see
a&a 425, 255 (2004)

summary

Nobody really knows how pulsars radiate, although several hundreds have been studied in some detail. The mechanism would have to work over vast ranges of spin periods (1ms - 8 seconds) and magnetic field strengths (10^8 - 10^{14} G). We investigate the extremes in this range for clues on the emission process. Work on fast pulsars is ongoing; in slow pulsars we already find evidence for an accelerating vacuum gap over the pulsar pole.

periodic behaviour within individual pulses

Although the average profile of a pulsar is very stable, the individual pulses can show a lot of variation. In some pulsars the positions of the pulse components even vary in a regular fashion from pulse to pulse. This fascinating 'subpulse drifting' (big figure on the left) is thought to be caused by a ring of discrete emitting regions at some distance above the neutron star surface (cf. figure 1). Each hot spot produces one peak in a single pulse. When the local magnetic and electric field force the hot spots to rotate around the magnetic pole the peaks in the pulse profiles will move as is observed.

Inverting the component movements we observe to determine what happens at the pulsar pole is problematic as we only get to sample the hot spot position once per pulsar period. To investigate the pulsar environment one has to break this so-called alias degeneracy (figure 2).

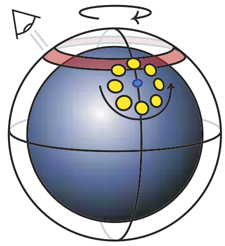
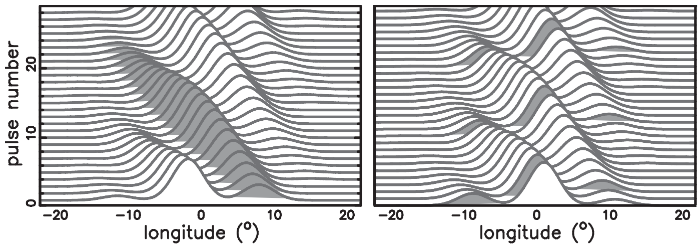


figure 1: Cartoon of a carousel-of-sparks model.

figure 2: The pulse aliasing problem. One spark, marked with a darker colour, can move with different speeds or directions and still create the same driftpattern.



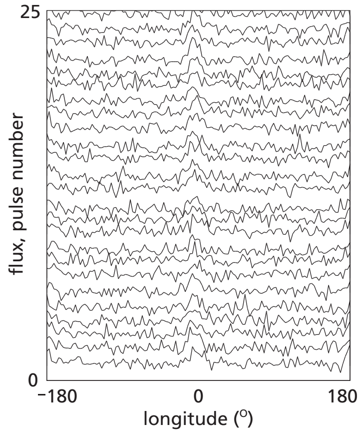
slow pulsars

In our example slow pulsar (PSR B0809+74) something strange happens, as can be seen in the large figure on the left. Around pulse number 20, the emission suddenly stops (a "null"). After a few seconds the pulses re-appear, but always with the position of the peaks unchanged. Apparently somehow the hot spots remember where they are even though they are physically gone.

We have looked at the subpulse-patterns after these null and find it takes one hot-spot over a few hundred seconds to make one full revolution around the magnetic pole; much longer than predicted. We also find that these patterns show all the signs of suddenly being emitted closer to the surface. After nulls, we look deeper into the pulsar magnetosphere. These findings are in quantitative agreement with a model that accelerates particles in a vacuum gap right over the pulsar surface. Higher up these particles then produce the radio emission we see.

fast pulsars

We are currently investigating the individual pulses of the second-fastest pulsar known (PSR B1937+21) with Arecibo, the world's largest telescope. With new pulses arriving every 1.5ms the individual pulses are not as bright as for slow pulsars but bright enough to use two-dimensional fourier transforms to find pulse-component periodicities.



conclusions

We find evidence that pulsar emission is caused by particles accelerated in a vacuum gap over the pulsar pole.