Detection of a Stellar Flare by Amateur Equipment

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Abstract: Since 1980, solar flare monitoring station A-52 has been detecting and reporting solar flares. At 1022UT on 1998 August 27, a powerful flare of the star magnetar SGR 1900+14 in Aquilla was detected by the Ulysses spacecraft and other space vehicles. The flare ionised earth's atmosphere and affected the propagation of low frequency radio signals. This was detected by NASA equipment but also by amateur station A-52, at Edenvale. It was the first known detection of a stellar flare by amateur equipment.

1. Solar flare monitoring

By way of introduction, it will be necessary to give a short description of the solar flare monitoring programme conducted by the AAVSO:

One cannot stare at the Sun all day long using a telescope equipped with an H-Alpha or K filter, waiting to observe a flare. Some observatories use automated equipment and at great cost, obtain a record of the Sun's behaviour in optical and radio wavelengths while it is not obscured.

The method of SID/SES (Sudden Ionospheric Disturbance/Sudden Enhancement of Signal) monitoring is just as sensitive as the professional equipment mentioned above and costs little to operate, is not affected by cloud and is effective even when the sun is below the horizon [see also *MNASSA*, 57, 9&10, Centrepiece].

When a solar flare erupts, the resulting emission reaches Earth in about eight minutes and increases the ionisation of the D layer of the atmosphere of the hemisphere facing the sun. The ionisation is almost instantaneous but takes minutes, sometimes hours to decay. Users of short wave radios are familiar with the fading which occurs when solar flares erupt. The ionised D layer does not reflect short wave signals effectively and weak reception results. On the other hand, the propagation of long wave signals is enhanced. We make use of this effect to detect solar flares.

Figure 1 shows the location of station A-52 and the three propagation paths usually monitored. It will be noticed that when the path over the Indian Ocean is in sunlight, the paths across the Atlantic are still in darkness and are not sensitive to solar flares. We can detect flares for about 20 hours a day.

Station A-52 consists of three home-built VLF receivers, feeding into a Rustrak strip

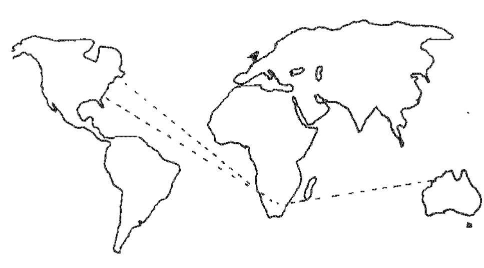

Figure 1: Propagation paths for 19.8, 21.4 and 24 KHz signals.

chart recorder. The receivers are tuned to 19.8, 21.4 and 24 kilohertz signals transmitted by military stations situated at North West Cape in Australia, Annapolis in Maryland and Cutler in Maine. (At the time of writing, the 19.8 signal is off the air, we hope temporarily).

Figure 2 below shows the trace of a typical strong flare on 1999-02-27. At that time, much of the the propagation path from Cutler, Maine, was in darkness and only a weak effect was recorded, compared with the other two. Of particular interest are the sinusoidal "sunrise waves" preceding the flare. These are an interference effect and are useful in showing that the equipment is functioning properly.

At the end of each month, the recording is carefully scanned and the sudden increases are "scaled" in accordance with a standard guideline and so converted into numbers. The numbers are e-mailed to the SES coordinator in the AAVSO's Solar Division who combines our numbers with those from elsewhere around the globe. He then sends a consolidated report to The National Oceanographic and Atmospheric Agency in Boulder, Colorado. NOAA issues regular bulletins, based on professional reports and data from amateurs, to scientific organisations worldwide.

Station A-52 started operating in 1980 and has reported hundreds of solar flares to the AAVSO. A few years ago, the first, efficient receiver was damaged by lightning and at this stage the second author joined in the activity. He has completely re-equipped and expanded the station and now operates it from his home, a few kilometres from the original site.

Solar flare monitoring is an ideal project for amateurs who want to do scientific work of real value but who cannot do optical work for one reason or another. It can also be a project for high school physics classes. Students can construct the equipment for a fraction of the cost of a personal computer or a usable telescope. The operation of the station will give plenty of scope for science teaching.

2. Detection of a stellar flare

On 1998 August 27 the Ulysses Spacecraft detected a gamma ray burst as illustrated in Figure 3 (overleaf). There was a dramatic rise at 1022UT followed by an asymptotic decay. It will be noticed that there are oscillations with a period of 5.16 seconds. These are probably caused by the same mechanism that activates radio pulsars, ie rotation of a small body.

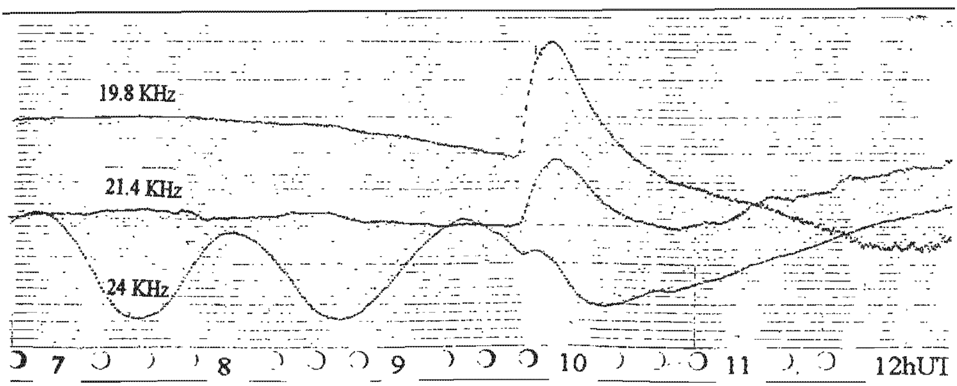

Figure 2: Solar flare of 1999 February 27 as recorded by the equipment at Station A-52, Edenvale.

The burst (from a so-called magnetar SGR 1900+14 in Aquila) also ionised the ionosphere's "D" layer, affecting radio propagation. The substellar point of the source was in the Marietta Islands in mid-Pacific, and consequently a propagation path between a transmitter in Hawaii and a receiver in Colorado could be affected.

After the burst was detected, the AAVSO asked amateur SES monitors to check their records of signals along the Hawaii-North America propagation path for unusual effects. For one reason or another, none of the North American observers detected anything unusual but a very sharp increase was found on Station A-52's record of the Australia-South Africa signal. About half of the propagation path was illuminated by the flare at the time. Figure 4 shows an enlarged portion of the trace.

This is apparently the first gamma ray burst detected by amateurs anywhere in the world.

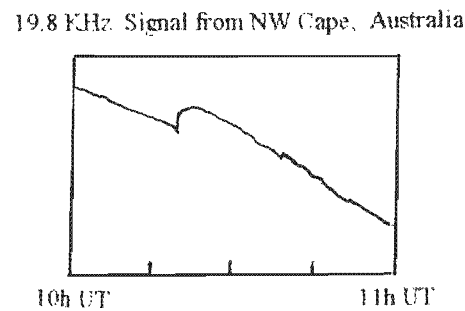

Figure 4: Gamma ray burst of 1998 August 27 as recorded by Station A-52 Edenvale.

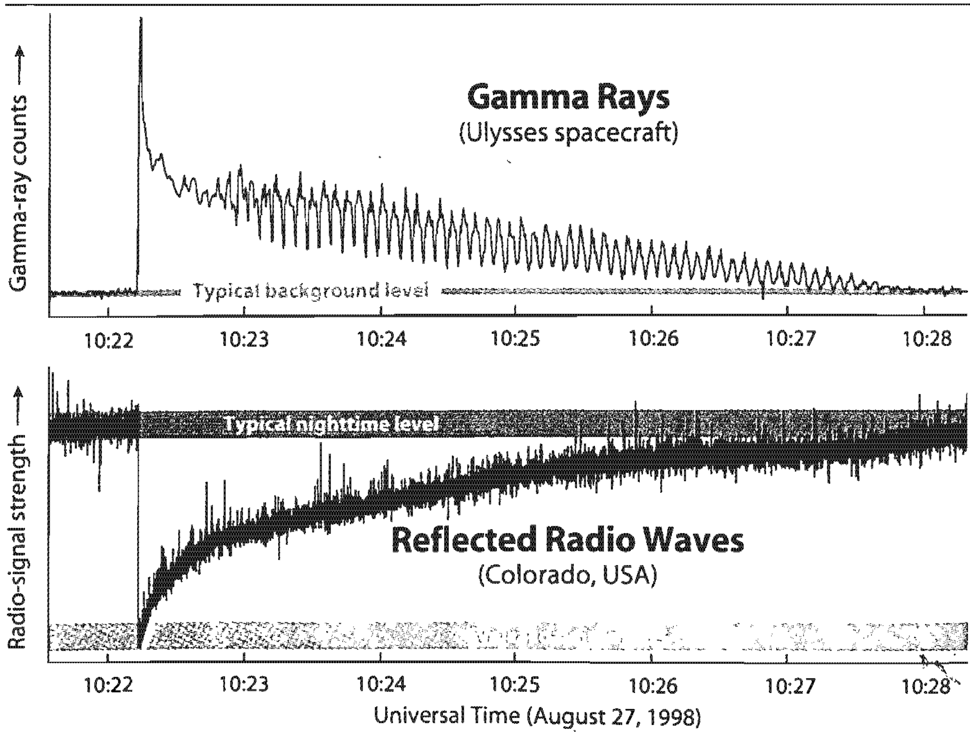

Figure 3