SIMULTANEOUS OPTICAL/GAMMA-RAY OBSERVATIONS OF GAMMA-RAY BURSTS

J. GREINER
Max-Planck-Institut für Extraterrestrische Physik
85740 Garching
Germany

1. Introduction

To search for optical counterparts of γ-ray bursters, a collaborative project has been initiated together with the γ-ray burst instrument team (BATSE) on the Compton Gamma-Ray Observatory (GRO) which provides times and locations of γ-ray bursts. On the optical part of this project, representatives of 10 observatories are presently involved.

2. Our Approach: Simply Waiting...

There are several photographic sky patrols still active in the world. In each cloudless night the available sky or specific regions are regularly photographed. The idea of our collaborative project is to wait for accidental coincidences of two completely independent sky surveys, i.e. these optical sky patrols and the BATSE monitoring of the γ-ray sky. That is, we search for sky patrol plates, the exposure time of which covers the time and the position of a GRB.

Previous results with this approach are rather sparse due to the lack of a large number of localised GRBs. The first attempt was made by Grindlay et al. (1974) who found time-correlated plates for 2 events at SAO out of a small set of localised bursts. Of ≈ 60 localised GRBs up to 1982 at $\delta \geq -20°$ and occurring during night in Middle Europe, time-correlated plates have been found for 5 events at the Ondřejov plate collection (Hudec et al. 1991), and for 1 event at Sonneberg Observatory (Greiner et al. 1990).

The photographic sky patrols of the observatories Sonneberg, Tautenburg and Hamburg (FRG), Calar Alto (Spain), Ondřejov (CR), Odessa and Crimea (Ukraine), and Dushanbe (Tadshikistan) are presently used for the northern hemisphere, and the Australian UK and ESO (La Silla, Chile) Schmidt plates for the southern hemisphere GRBs.

With BATSE detecting and localising approximately one GRB per day (since April 1991) we identify, on average: ≈ 15 simultaneous plates per year with 150° x 150° field-of-view (FOV) and limiting magnitude of 1 - 3 mag.; ≈ 1 simultaneous plate per year with 20° x 20° FOV and limiting magnitude of 6 - 8 mag.; ≈ 10 - 15 near-simultaneous (± 10 hours) plates per year with 5° x 5° FOV and limiting magnitude of 12 - 14 mag.

The limiting magnitudes refer to the sensitivity for a 1 sec duration flash within the exposure time of typically 0.5 - 4 hours. Up to now, no optical activity has been found within the typical

H. T. MacGillivray et al. (eds.), Astronomy from Wide-Field Imaging, 57–59.

5° – 10° error boxes which could be related to a GRB. Details on these simultaneous and near-simultaneous plates can be found elsewhere (Greiner et al. 1993).

3. Waiting vs. Rapid GRB Response

Recognising the importance of simultaneous optical observations of relatively large GRB error boxes, two procedures have been established 1) solely BATSE, 2) BATSE and COMPTEL (Ryan et al. 1993), during the last year in order to determine the GRB location as quickly as possible.

If BATSE detects a strong GRB during real-time contact between GRO and the ground station, its preliminary position is determined within a few hours. More detailed analysis leads, in general, to a refinement of the burst location within the next day. About 10 GRBs per year are currently localised in this timely manner.

If a burst happens to occur in the FOV of the Compton telescope COMPTEL, its imaging properties are used to derive a burst position (Ryan et al. 1993). Burst trigger as well as identification of bursts within the COMPTEL FOV are supplied by BATSE. Typically 3 - 5 GRBs per year occur to be quickly localised with this approach.

The typical time for the above described rapid response is of the order of 3 - 6 hours. The location accuracy is of the order of 5° - 10° radius for the BATSE and 3° - 5° radius for the BATSE/COMPTEL approach. The fastest optical response for the most favourable burst (GRB 930131) so far was 14 hours after the event. Due to the small FOV of this observation and the shifting of the location the final error box was not covered. The first observation covering the final error box was 35 hours after the GRB with a limiting magnitude of 13 mag for a 1 sec flash (Schaefer et al. 1993).

At present, the simple approach of a correlation of independent sky surveys is still identifying more timely and numerous optical observations than the rapid response approach. However, the latter is also applicable to quick counterpart searches at other wavelengths (especially radio observations) where no wide-field patrols are being performed.

4. Conclusion

We are interested in the participation of any group/institution which regularly monitors the sky and fulfils the following two conditions: 1) monitoring with wide-field optics covering at least 5 square degrees or more (preferentially 30 - 100 □°); 2) if later on an exposure turns out to be simultaneous with a γ-ray burst and to cover its error box then it has to be checked for optical variability. This is best done by comparing with an identical exposure from a different date/time. If such plates are not routinely exposed it should be possible to obtain a comparison exposure of the same area of the sky, with the same optics, scale, filter and roughly same limiting magnitude.

So far, only photographic patrols are used, but this restriction is not mandatory. With the development of large FOV CCD mosaics, electronic detectors become increasingly interesting due to their higher sensitivity at much better temporal resolution.

References

Greiner, J., Laros, J.G., Fenimore, E.E. and Klebesadel, R.W., 1990. *Astron. Astrophys.*, **227**, 115.

Greiner, J., Wenzel, W., Hudec, R., Pravec, P., Rezek, T., Nesvara, M., Moskalenko, E.I., Karnashov, A., Metlov, V., Cheniych, N.S., German, V.S., Kouveliotou, C., Fishman, G.J., Meegan, C.A., Paciesas, W.S. and Wilson, R.B., 1993. In 'Compton Gamma-Ray Observatory', AIP Conf. Proc. **280**, p. 828.

Grindlay, J.E., Wright, E.L. and McCrisky, R.E., 1974. *Astrophys. J.*, **192**, L113.

Hudec, R., 1991. Prep. Astr. Inst. Ondřejov, No. 120. (*Astrophys. Lett. and Comm.*, in press).

Ryan, J., Kippen, M., Varendorff, M., Macri, J., McConnell, M., Webber, W.R., Schönfelder, V., Greiner, J., et al., 1993. *Astrophys. J.*, in press.

Schaefer, B.E., Barthelmy, S.D., Palmer, D.M., Cline, T.L., Hurley, K.C., Sommer, M., Boer, M., Niel, M., et al., 1993. *Astrophys. J.*, in press.