A different kind of Universe

Giovanni F. Bignami

ON 17 November, γ-ray astronomy could be said truly to have come of age, as that was the day that the Compton γ-Ray Observatory, in orbit since April last year, completed the first-ever all-sky γ-ray survey. The significance of its mission became apparent at a meeting shortly before*, held suitably enough at Arthur Compton's old university, at which the results of the first 18 months were reviewed.

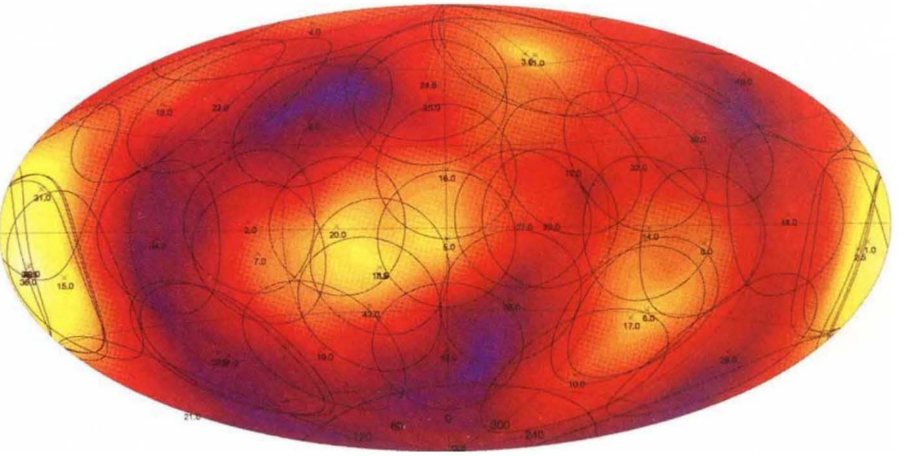
The Compton Observatory has a complement of four instruments covering the γ-ray energy spectrum from 30 keV to 30 GeV and capable of imaging the γ-ray sky, recording individual spectra and monitoring rapid variations and bursts from single sources. The meeting was more than a celebration of the satellite's capabilities; it was also a shop window for those looking to bid for time on the mission's third cycle.

Among the Compton Observatory's early spectacular successes was the discovery of the brightest source of γ-rays, in the distant quasar 3C279 (see my News and Views article, *Nature* **355**, 299; 1992). A further 15 γ-ray quasars have since been discovered by the same instrument (EGRET, Energetic Gamma Ray Experiment Telescope), thanks to its sensitivity and ability to pinpoint sources. And COMPTEL (Compton Telescope) and OSSE (Oriented Scintillation Spectrometer Experiment) have seen several more. Although diverse in character and at a wide range of distances, the sources are all very powerful at radio wavelengths and are probably all characterized by a high degree of beaming along an axis. There were critics of γ-ray astronomy who did not believe it could give useful accuracy in pinpointing sources, but it is inconceivable that all the γ-ray quasars have been misidentified, especially as Compton's targets were carefully selected in advance. Instead, astrophysicists should now come to grips with the task of explaining how active galaxies come to radiate more energy at γ-ray wavelengths than over all the rest of the electromagnetic spectrum (even when the effects of beaming are accounted for).

The Compton Observatory has also dealt a severe blow to the idea that the bulk of the cosmic ray background comes from beyond our Galaxy — that is from other galaxies. Using EGRET, the Compton team used a test proposed long ago by Vitaly Ginzburg, looking for γ-rays from the Magellanic clouds — the two small satellite galaxies in orbit about our own. The Small Magellanic Cloud, so far at least, appears to emit no γ-rays.

That brings much of γ-ray astronomy into the galactic domain. Several hundred pulsars are known, all recognized through their distinctive radio pulsations, but despite theoretical predictions that these should produce copious γ-rays, only two (the Crab and Vela pulsars) had previously matched expectations. Their γ-ray emissions had been discovered in the 1970s by the SAS-2 astronomical satellite, and were subsequently confirmed by COS-B. With EGRET detections, that number has now more than doubled: pulsed γ-rays at energies above 100 MeV energy have been seen from Geminga — long known as a point source of γ-rays that defied explanation (see C. D. Bailyn's News and Views report in *Nature* **357**, 191; 1992) — and from the less notorious pulsar PSR1706−44.

Like the Crab and Vela examples, PSR1706−44 is a *bona fide* radio pulsar, but its γ-ray phase pattern is somewhat different. Geminga, it now appears, is our closest pulsar, but its geometry seems to have prevented us from seeing any radio signal from it. At lower energies, γ-ray pulsars are apparently harder to find, nevertheless COMPTEL and BATSE (Burst and Transient Source Experiment) have identified pulsed γ-rays below 10 MeV from Vela, as well as sub-MeV γ-rays from PSR1509−58.



Painting the sky red: sky coverage by the Compton Observatory on its first survey, colour coded (blue to yellow) for exposure times in days (4–20). Fields of view of individual pointings are also shown.

Compton has also taken simultaneous observations of the spatial and spectral distributions of the 511-keV radiation produced by the annihilation of positrons on electrons (an indicator of an energetic astrophysical environment) and the 1.8-MeV radiation from radioactive aluminium-26. OSSE data show the annihilation radiation to be sharply peaked at the Galactic Centre, where its spectral shape is very narrow; there is, however, a significant spectral tail, indicative of the formation of the electron–positron 'atom', positronium. For both lines, whether the diffuse emission comes from genuinely diffuse sources or from unresolved point-like sources is not clear. Distinct sources would be expected for the 1.8-MeV line, as this is the product of the magnesium–aluminium nucleosynthesis cycle which occurs in supernovae, nova outbursts, Wolf–Rayet stars and so on.

The most celebrated of all the results from Compton, touched on many times in these pages, concerns γ-ray bursts — brief outbursts of γ-radiation, typically not repeated from any particular source — whose origin remains a complete mystery. In the absence of any better means of resolving the debate, the conference organizers resorted to the unorthodox but democratic method of a show of hands. The galactic and extragalactic parties polled even support; sources in the Solar System gathered a few votes. But there was a substantial rump in support of an agnostic approach — perhaps the most sincere position given the self-contradictory character of the Compton data. □

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Correction

In the article dealing with the mechanism by which β-lactamase nullifies the effects of penicillin (*Nature* **359**, 674; 1992), it was stated that the antibiotic ampicillin (the correct spelling), is resistant to β-lactamase; it is in fact sensitive. In the same article glutamine 166 should have read glutamate 166.

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