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Gamma Ray Emission from Chaotic Winds

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PROJECT SUMMARY

The purpose of this proposal was to search for gamma-ray emission from the winds of hot, massive stars. According to our theoretical calculations (Chen & White 1990, 1991a,b,c; White & Chen 1992a,b), shocks in the winds of massive stars accelerate particles to high energies. The high-energy particles emit synchrotron radio emission (observed by ground-based radio telescopes) and high-energy gamma-ray emission that we predicted should be detectable by the EGRET instrument on the Compton Gamma Ray Observatory between 100 MeV and a few GeV.

We obtained EGRET data from Phases 1, 2, and 3 of the Cygnus OB2 association, a cluster of massive, young stars, to search for this gamma-ray emission. The data products and analysis show a source consistent with the position of Cyg OB2 with approximately the predicted count rate and spectrum. Analysis of these data is made difficult by two complications:

(1) The Cyg OB2 cluster is only about 0.3 degrees away from the bright X-ray source Cygnus X-3. Cyg X-3 has been detected in hard X-rays, and a detection in ultra-high energy gamma-rays has also been claimed (though some astronomers have expressed skepticism about this result.) A power-law interpolation between the hard X-ray and UHE gamma-ray observations predicts a flux at EGRET energies that is a somewhat below both our prediction for Cyg OB2 and the detected count rate; nonetheless, we need to make a convincing case that the observed gamma-rays come from the Cyg OB2 association rather than Cygnus X-3.

(2) The gamma-ray background in the Cygnus region is complex, with considerable structure. Accurate modeling and subtraction of the background is a crucial step both in the search for gamma-ray emission from Cyg OB2 and in establishing an accurate position for the source.

The results from our data analysis were a tentative conclusion that we did indeed detect the predicted gamma-rays from Cyg OB2 (White & Chen 1994, 1995; Chen, White, & Bertsch 1996). The position of the observed gamma-ray source is consistent with the position of Cyg OB2, but is marginally inconsistent (at the 90% confidence level) with the position of Cyg X-3. This inconsistency becomes more significant when the position is computed using only higher-energy photons (which are better localized in the EGRET detector.) At energies above 2 GeV, the position of the detected gamma rays is inconsistent at the 2-sigma level (95% confidence) with the position of Cyg X-3, but is consistent with the Cyg OB2 cluster. Furthermore, the detected gamma-ray photons show no evidence for the 4.8-hour modulation that is seen in observations of Cygnus X-3 at all other energies. Taken together, the observations provide good evidence that the Cygnus OB2 cluster of massive stars is a source of gamma-rays, but we are still unable to definitively rule out Cyg X-3 as the gamma-ray source.

While we were analyzing the CGRO data, we also continued our theoretical work on gamma-ray emissions from hot stars. Chen & White (1994) and White & Chen (1995) reported new theoretical calculations of the gamma-ray emission predicted from particles accelerated by the shock in colliding wind binaries. These papers also included more constraints on the shock-acceleration of high energy particles from the observations of radio synchrotron emission. Copies of all these papers are attached.

REFERENCES

Copies are attached for those marked *, which were supported by this grant.

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