Summary(1)

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abstract

A summary of the symposium is presented from a theorest' point of view.

1. INTRODUCTION

The symposium *The Universe Viewed in Gamma-Rays* was held at the time when the first decade of high energy gamma-ray astronomy had revealed a handful bright sources and when the new epoch is just beginning with several larger facilities under construction. In the symposium many interesting presentations were made on many different topics. Since larger telescopes such as HESS, MAGIC, VERITAS and CANGAROO III are just being constructed, at the time of the symposium we did not see a flood of new data which will be surely provided in a few years except for the new data reported from CANGAROO II and others, which have given new insight into high energy processes in the universe. Results with Chandra X-Ray Observatory were also exciting topics because of their detailed images with high spatial resolution.

At the present stage, the number of confirmed sources of high energy gamma-rays is around 10. Those include pulsar nebulae such as Crab, PSR1706-44 and Vela, supernova remnants such as SN1006 and RXJ1713.7, blazar type of Active Galactic Nuclei such as Mrk421, Mrk501 and others. But, symptoms of sources of new categories were also reported including the first unidentified point source in the TeV region (Pohl) and the star burst galaxy NGC253 (Itoh). Clusters of galaxies become new targets in exploring the origin of cosmic rays in external galaxies and in the cosmological contexts (Völk).

2. PULSARS

Theoretical understanding of high energy processes in the universe consists of three elements, i.e., relativistic outflow, shock wave dissipation and particle acceleration. In this symposium, a series of high resolution maps of the Crab

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Nebula made with HST and Chandra are presented and used to give us new perspectives on these issues (Slane, de Jager, Shibata). These maps show the change of the spatial structure in the nebula such as rings, knots and jets; the wisps are observed to move outwards with the speed at half of the light velocity.

Standard model of the Crab nebula assumes that the central pulsar produces relativistic $e^{\pm}$ wind with the bulk Lorentz factor around 10^7, where the Poynting flux is below 1% of the kinetic flux. The strong shock generated at around 0.2pc is responsible for particle acceleration and synchrotron nebula. This picture is consistent with the emission spectrum from infrared to very high energy gamma rays within the single zone model. However, HST and Chandra view revealed many fine structures, which requires more detailed modelling of the Crab nebula. Shibata presented a first step to interpret these maps and suggested a possibility of higher Poynting flux and smaller bulk Lorentz factor than the standard model to explain the observed features.

3. SUPERNOVA REMNANTS

Supernova remnants were the most highlighted topic in this symposium (Slane, Tanimori, Berezhko, Bamba), in particular, focus was put on the Chandra view of SN1006 (Bamba) and on CANGAROO II result on RXJ1713.7 (Tanimori).

Tanimori presented the CANGAROO II observation of RXJ1713.7 and claimed that the steep sub-TeV spectrum is the first evidence for proton acceleration in the supernova remnant. This claim seems to be viable because an alternative interpretation with inverse Compton scattering of CMB photons does not reproduce the observed X-ray emission within the homogeneous model. But, some problems were also pointed out with the consistency with EGRET flux and with the effects of inhomogeneities. For example, if magnetic field is distributed inhomogeneously, synchroton emission becomes also inhomogeneous without an excess emission of high energy gamma-rays. In fact, as is discussed below, X-ray emission from SN1006 is concentrated in thin filaments. Thus, we must wait some more time until we find conclusive evidence for proton acceleration in supernova remnants.

Bamba presented Chandra view of SN1006 and showed that its north-east shell actually consists of many thin filaments with a scale length as small as 0.01 to 0.1pc. She presented an analysis based on the diffusive shock acceleration and argued that the shocks are oblique to explain the smallness of the scale length. The strength of the magnetic field is an order of magnitude higher than the previous model based on the spectral fitting. This indicates that the emission region of X-ray synchrotron radiation and that of high energy gamma-rays by the

inverse Compton scattering of CMB photons are not completely the same. As was discussed above, synchrotron emission should be more inhomegeous.

This observation also provides important implications for the particle acceleration process in the shock waves. Berezhko presented gamma-ray emission of hadronic origin comparing with observations based on diffusive shock acceleration. Hoshino presented surfing machanism of electron acceleration in which electrons are trapped in the soliton-like structure of perpendicular collisionless shocks. Since observations are revealing fine spatial structures around shock fronts, it is important to develop theories incorporating the internal structure of shocks like this and confront with detailed observations.

4. BLAZARS

For blazars, a few more TeV blazars have been reported in addition to Mrk421 and Mrk501 and efforts of detailed modelling have been continued based on multiwavelength observations. Coppi summarized the present situation of modelling. Although the basic internal shock model in relativistic jets is considered to be a correct one, simple one-zone model faces some difficulties with interpretation of flares of Mrk421 and Mrk501. We note that for blazars in addition to inhomegeneities, time dependent behaviour is also important to properly explain available observations and to obtain theoretical implications for particle acceleration mechanisms.

Another important topic on blazars is the relevance of cosmology, especially, of the infrared background radiation. Multi-TeV emission of Mrk421 and Mrk501 seems to show a cutoff at around $3 \sim 6$TeV and is expected to suffer from strong intergalactic absorption against pair production. Dwek gave a detailed account of the direct measurements of the infrared background and suggested that the best estimate is around $5 \sim 10 \mathrm{nWm}^{-2}\mathrm{sr}^{-1}$ in the relevant energy range. This relatively low value is consistent with the multi-TeV observations of Mrk421 and Mrk501 and no significant crisis remains now.

Summarizing, this symposium highlighted the importance of high spatial resolution and multiwavelength observations and theoretical efforts for incorporating inhomogeneities. Facilities of high energy gamma-rays now in construction, such as VERITAS, HESS, MAGIC and CANGAROO III as well as GLAST mission will bring us with more surprises as well as increasing number of TeV sources in the coming years.