On the Seed Particles of Very High Energy Photons from SN1006

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Abstract— **In this paper, the authors discuss the seed particles of very high energy (VHE) photons from SN1006 observed by the HESS collaboration. We propose here that charged particles produced by the stellar flares are the seed particle. They are injected into the rim of the Super Nova Remnants continuously and accelerated from 1GeV to 100 TeV. The flux of TeV gamma-rays from SN1006 can be naturally reduced by this hypothesis.**

Where the seed particles of GCR are coming from is a longstanding question in cosmic ray physics. Whether they are coming from the stellar matter or they are coming from super nova. (See Figure 1, prepared by Prof. Lingenfelter in the cosmic ray conference at Tasmania)

The charged particles emitted into the space in the time of Super Nova explosion are tightly trapped by the magnetic field of the blast wave induced by the explosion. So they cannot escape from the rim of the shock wave. If these particles cannot escape from the shock wave region, they will be NOT accelerated by the shock. Particles will be not accelerated unless otherwise particles have the Lorentz factor higher than the shock wave, i.e., the velocity of particles has the value higher that ≥1/10 of the light speed c.

Therefore the author would like to propose a new idea that **the seed particles are produced in other stars and transported up to the SNRs.** There are plenty of stars in our Galaxy and they will frequently make flares. They are called as "stellar flares", possibly having an analogy with solar flares. In this paper we only assume one simple hypothesis that the intensity of the ions induced by the stellar flares is nearly the same magnitude as observed proton flux near the Earth around 1-10GeV and for the electron flux: the flux observed by Voyager and Pioneer around 10MeV.

Then injected particles from outside of the rim are repeating the back and forth motion, crossing the rim of the shock front. At that time they will obtain the additional momentum from the shock front and they are accelerated up to 100 TeV. By the acceleration, the Larmor radius of particles will increase and exceed the size of the rim. At that time, particles will get already high momentum like 1000TeV/c. Then the acceleration process will be terminated.

The authors demonstrate that these hypotheses can reproduce the observed flux of very high energy gamma-rays from SN1006 by the HESS collaboration, being based on a very simple "order calculation".

In Fi.2 we draw the acceleration process and in Fig. 3 we show the flux of accelerated particles. Here we will write fundamental numbers that are necessary for the discussions.

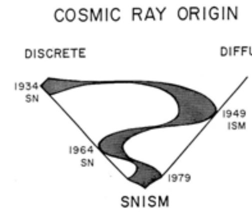

Fig.1

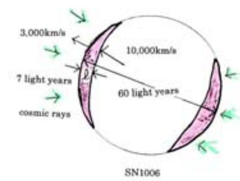

Fig. 2

1 light year ≈ 10^{13} km , 1 year =3.15×10^{7}sec
60 light year ≈ 5.7×10^{14} km (the diameter of SN1006)
30 light years ≈ r≈ 2.9×10^{14}km (the radius of SN1006)
$4\pi r^2$ ≈ 1.07×10^{30}km^2 ≈ 1.07×10^{36}m^2
7 light years ≈ 7×10^{13}km (the width of the rim by gamma-rays)
1.3 light years ≈ 1.3×10^{13}km (the width of the rim by X-ray satellite Newton)
P=300H ρ = $3\times10^2 \times (10\times10^{-6})$ gauss $\times (1\times10^{18})$ cm ≈ 3×10^{14}eV ≈ 300TeV

Ions peed 130km/sec $v_i=\sqrt{2kT/m_i}$, Electron speed 5500km/s $v_e=\sqrt{2kT/m_e}$
for T= 10^6 K and Alfven speed =220km/s
for ions v ≈ 1/300c (10keV), v ≈ 1/30c (1MeV) v ≈ 1/3c (100MeV)

The volume of the rim ≈ 2×10^{52} m^3, the position of SN1006 ≈ 7,100 light years
$4\pi\ell^2$ ≈ 6.3×10^{40}m^2, $1/4\pi\ell^2$ ≈ 1.6×10^{-41}/m^2 (detection efficiency)
Flux of particles at 10 GeV : 10^3 particles/m^{2}sec
Collision rate: $n\sigma\ell$ ≈ 2.8×10^{-8} collisions/particle for ℓ ≈ 7 light years,
density of protons n≈ 0.1 proton/cm^3 and cross-section σ ≈ 40mb
collision rate≈ flux$\times n\sigma\ell$ ≈ $10^3\times(1.07\times10^{36}m^2)\times2.8\times10^{-8}$ ≈ 2.8×10^{31}/sec
Detection flux of γ-rays ≈ 2.8×10^{31}/sec$\times1.6\times10^{-41}$/m^2≈ 3×10^{-10}/m^{2}sec
Observed results by HESS ≈ 3×10^{-10}/m^{2}sec over 3 TeV of photons.

ΔE/E ≈ $(1+2\times v/c)^n$ ≈ 10 (one order up)
≈ $(1+2\times1/100)^n$ ≈ 10 n ≈ 116
≈ $(1+2\times10{,}000/300{,}000)^n$ ≈ 10 n ≈ 36

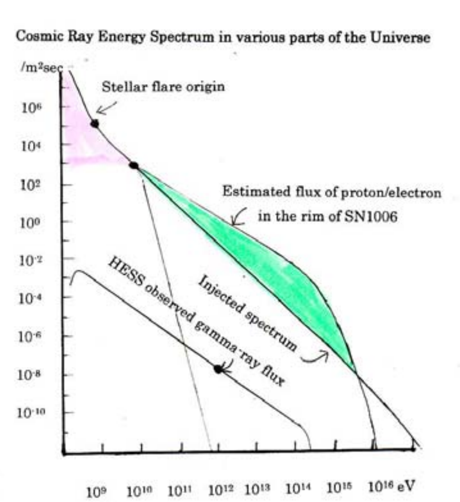

Fig. 3