Active Galactic Nuclei: from Central Engine to Host Galaxy
ASP Conference Series, Vol. xxx, 2003
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How relevant is the torus activity/geometry for the TeV gamma-rays emitted in the jet of M87 ?

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Abstract. Motivated by unification schemes of active galactic nuclei, we review evidence for the existence of a small-scale dust torus in M87, a Fanaroff-Riley Class I radio galaxy. Since there is no direct evidence of any thermal emission from its torus we consider indirect evidence, such as BLR activity and ageing arguments to model the cold dust structure of M87. In the context of the jet – accretion disk – torus symbiosis we discuss the interactions of GeV and TeV gamma-rays produced in the jet of M87 with the infrared radiation fields external to the jet, produced by a less active torus. A thin and cold torus with less defined outer boundaries could still posses problems to some of the TeV emission from the jet.

1. Introduction

We have already discussed in Donea & Protheroe (2002) some aspects related to the IR radiation from ubiquitous dusty tori in quasars and some blazars. We have shown that the torus radiation could present a serious problem for the escape of TeV γ-rays from emission regions which are not well above hot tori.

It is hard to accept that M87, a mis-aligned BL Lac object, that posses a huge black hole (Ford et al., 1995), a very active jet (Wilson et al., 2002) and BLR (Sankrit et al., 1999) and possibly NLR (Zavala & Taylor, 2002), completely lacks the dusty component, be it very cold. M87 has a low luminosity nucleus and the fact that strong mid-infrared emission was not detected from the centre of M87 (Perlman et al., 2001) suggests either that there is no torus in M87, or if there is one it should have a low radiative efficiency making its detection difficult. Using argument related to the age of M87, the fact that M87 could undergo on-off activity cycles (Di Matteo et al., 2002) and the possibility that M87 could harbour a double black hole system (Zier & Biermann, 2001) we assume that M87 could still have sufficient dust around its nucleus (Fig. 1a).

We calculate the optical depth for γ-γ pair-production $\tau_{\gamma\gamma}$ of GeV-TeV photons emitted by the jet interacting with IR photons from the torus (Fig. 1b). Bai and Lee (2002) have suggested that M87 could emit detectable TeV photons with an inverse-Compton emission peak at only 0.1 TeV. Protheroe et al. (2002) have predicted that γ-ray emission involving hadronic interactions cuts off at 10 GeV - 1 TeV, depending on the luminosity of the low hump of SED. We find that γ-rays with energies around 0.1 TeV are not absorbed by the IR cold photons and therefore could be detectable. Although the high temperature of

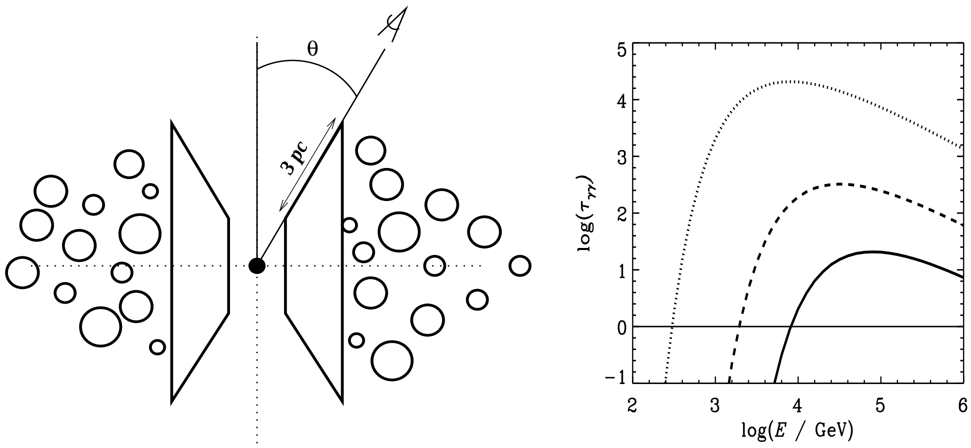

Figure 1. a) The main body of the torus of M87 is assumed to be cold with $R_{\rm in} \approx 1$ pc., $R_{\rm out} \approx 2.5$ pc, and its cross section being trapezoidal with its inner edges cut away at angle $\phi = 30°$. For $R > R_{\rm out}$ the dust is highly inhomogeneous ending up in an diffuse dust-boundary. b) Optical depth for the absorption of GeV–TeV photons travelling along the jet from the central 0.001 pc, in the weak infrared bath of photons from this torus. The curves are calculated for different temperatures of the dust $T_0 = (100, 250, 1000)$ K (from bottom to top).

1000 K is unrealistic for the present near-dormant state of M87, it is interesting to see what the difference would be in absorption when M87 would power on the torus.

We note that γ-rays with energies above 10 TeV (if produced) could be absorbed even when the torus is cold ($T = 100$ K) and thin, and the emission region lies within the torus. As one moves away from the black hole, the TeV emission if produced in the jet, escapes the γ-γ absorption and could be detected by the Cherenkov telescopes. We conclude that the absorption of GeV to 10 TeV photons by γ-γ interactions with the infrared photons produced by a cold torus is negligible. Only a strong and rapid ignition in the nucleus of M87 could heat up the dust and increase the absorption of γ-rays produced nearby the infrared torus.

References

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