Suzaku observations of the most distant TeV blazars

A. Reimer1, L. Costamante2, G. Madejski2 & O. Reimer1

1 Stanford University, HEPL/KIPAC, Stanford, CA 94305, USA; 2 Max-Planck-Institut für Kernphysik, D-69117 Heidelberg, Germany; 3 Stanford University, SLAC/KIPAC, Menlo Park, CA 94025, USA

Abstract

55 ksec Suzaku observations for each of the two most distant TeV-blazars known to date, IES 1101-232 and IES 1553+113 were carried out in May and July 2006, respectively, with quasi-simultaneous coverage at TeV-energies. We report on first results of this campaign. The spectral X-ray analysis of the combined XIS-PIN data reveals deviations from a simple power-law for both blazars, and indicate a softening with increasing energy. IES 101-232 was found in a quiet state with the lowest X-ray flux ever measured, and no sign of variability.

1 Introduction

The spectral energy distribution (SED) of blazars is generally interpreted as synchrotron and inverse Compton emission from relativistic pairs which upscatter their self-produced synchrotron radiation or external photon fields. Hadronic models produce the high energy peak either via interactions of relativistic protons with matter, ambient photons [7], and/or magnetic fields [1,9]. All TeV-blazars detected to date belong to the subclass of high-frequency peaked BL Lacs, with their two \( \gamma - \)Peaks typically at UVX-rays and TeV-energies. TeV-blazars are a powerful tool to probe the extragalactic background light (EBL) at IR/opt. energies through absorption of \( \gamma - \)rays in the diffuse radiation field. We were awarded 55 ksec on two of the most distant TeV-blazars known to date: IES 1101-232 and IES 1553+113. These observations were covered by quasi-simultaneous observations with the H.E.S.S. telescope system. None of these sources have been shown in the past significant variability at TeVs [2,3], likely owing to their low TeV-flux level close to the detection limit.

2 Suzaku analysis

IES 1101-232 has been observed by Suzaku in May 25-27 2006 for a total of 53.1 sec on-source, IES 1553+113 in July 24-25 2006 for a total of 41.1 sec on-source, both at the HXD nominal point. The data analysis is based on the version 1.2.3 processed data with the standard mkf filtering. For the XIS-data analysis the build-up contamination were taken into account by utilizing the xissim marken Carlo to produce the appropriate air files. The IES 1101-232 PIN data contained a large background "flare" occurring towards the end of our observations. Therefore we considered the PIN data only up to MD 53941,7 for this analysis where the background behaves as expected. The PIN data of IES 1553+113 suffered from a 10% higher background than expected, which we take into account in our analysis by appropriate normalization. In all other steps we applied the standard analysis procedure. For the spectral analysis of the combined time-integrated XIS and PIN data we have taken into account the Cosmic X-ray background [5] normalized to the PIN field-of-view, and a XIS/IXD normalization of 1.16 [6].

3 Results on IES 1101-232

We detected IES 1101-232 with Suzaku up to ~30 keV. The combined fit revealed a significantly improved \( \chi^2 \) statistics when fitting to a broken power law (\( \chi^2 = 1.10 \)) as compared to a single power law (\( \chi^2 = 1.27 \)). Best-fit parameters are: \( \alpha_1 = 1.78^{+0.12}_{-0.16}, \alpha_2 = 2.29 \pm 0.01, E_{\text{break}} = 0.77^{+0.06}_{-0.04} \text{keV}, \) with an average 2-10 keV flux of 1.9 \( 10^{-11} \text{erg cm}^{-2} \) and a 10-30 keV flux of 1.8 \( 10^{-13} \text{erg cm}^{-2} \). This is the lowest flux level ever measured from this source. The absorbing column density was fixed to a galactic \( N_H = 5.76 \times 10^{22} \text{cm}^{-2} \).

The observed low flux level and lack of variability indicates an overall quiescent flux state of IES 1101-232 during the Suzaku observations. The average spectrum was only slightly harder than during the 2006 X-ray and UVX observations in 2001 (\( \alpha = 2.1 - 2.1 \)) [10], where also no significant variability was noticed. The 1997/98 BeppoSAX observations [4] had 40-80% higher break energies at a 30% higher flux level. The overall low-energy \( \nu F(\nu) \), peaked \( \sim 0.2 \) keV during our observations.

4 Results on IES 1553+113

We report a detection of up to 25-30 keV for IES 1553+113. Though deviations from a power law at \( <0.5 \) keV remain (possibly from still unresolved contamination problems), the overall spectral fit improves when fitting to a broken power law (\( \chi^2 = 1.26 \)) as compared to a single power law (\( \chi^2 = 1.46 \)). Best-fit parameters: \( \alpha_1 = 2.29 \pm 0.01, \alpha_2 = 2.52 \pm 0.01, E_{\text{break}} = 2.50 \pm 0.09 \text{keV}, \) with an average 2-10 keV flux of 3.24 \( 10^{-12} \text{erg cm}^{-2} \), and a 10-30 keV flux of 1.74 \( 10^{-13} \text{erg cm}^{-2} \) (absorbing column density fixed to a galactic \( N_H = 3.67 \times 10^{22} \text{cm}^{-2} \)). This flux level and spectral shape is compatible with the 2004 flux state (XMM [10]).

The spectral shape and flux deduced from the present data is in agreement with the latest published XMM spectrum [10], which indicates spectral curvature that softens with energy. The 1998 BeppoSAX observations [4] had a significantly lower break energy (~1 keV) at a 60% lower flux level. The overall low-energy \( \nu F(\nu) \), peaked \( <0.2 \) keV during our observations.

IES 1553+113 has no spectroscopically or photometrically determined redshift. TeV observations were recently used to set redshift limits \( z < 0.74 \) and \( < 0.2 \) [2,8], Fig. 5 shows the overall SED with the latest but non-contemporaneous data, including the present Suzaku spectrum. If corrected by the minimal EBL, as deduced in [2], equal or more power is emitted at \( \gamma - \)rays than at the synchrotron hump with a \( \gamma - \)ray peak beyond TeVs.


AR acknowledges support from NASA grant NNX07AB19G.