The afterglow and the host galaxy of GRB 011211Based on observations made with the Nordic Optical Telescope, operated on the island of La Palma jointly by Denmark, Finland, Iceland, Norway, and Sweden. Based on observations made with ESO Telescopes at the Paranal Observatory by GRACE under programme ID 69.D-0701. Based on observations made with the NASA/ESA Hubble Space Telescope, obtained from the Data Archive at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. These observations are associated with program #8867.

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We present optical, near-infrared, and X-ray observations of the optical afterglow (OA) of the X-ray rich, long-duration gamma-ray burst GRB 011211. Hubble Space Telescope (HST) data obtained 14, 26, 32, and 59 days after the burst, show the host galaxy to have a morphology that is fairly typical of blue galaxies at high redshift. We measure its magnitude to be $R = 24.95 \pm 0.11$. We detect a break in the OA $R$-band light curve which is naturally accounted for by a collimated outflow geometry. By fitting a broken power-law to the data we find a best fit with a break $1.56 \pm 0.02$ days after the burst, a pre-break slope of $\alpha_1 = -0.95 \pm 0.02$, and a post-break slope of $\alpha_2 = -2.11 \pm 0.07$. The UV-optical spectral energy distribution (SED) around 14 hours after the burst is best fit with a power-law with index $\beta = -0.56 \pm 0.19$ reddened by an SMC-like extinction law with a modest $A_V = 0.08 \pm 0.08$ mag. By comparison, from the XMM-Newton X-ray data at around the same time, we find a decay index of $\alpha_X = -1.62 \pm 0.36$ and a spectral index of $\beta_X = -1.21^{+0.10}_{-0.13}$. Interpolating between the UV-optical and X-ray implies that the cooling frequency is located close to $\sim 10^{18} \text{Hz}$ in the observer frame at the time of the observations. We argue, using the various temporal and spectral indices above, that the most likely afterglow model is that of a jet expanding into an external environment that has a constant mean density rather than a wind-fed density structure. We estimate the electron energy index for this burst to be $p \sim 2.3$. cosmology: observations – gamma rays: bursts – supernovae: general – dust, extinction

The afterglow and the host galaxy of GRB 011211

P. Jakobsson et al.

Introduction A deceleration of a relativistic fireball in the surrounding environment is now widely believed to cause the afterglow emission of GRBs (see Piran piran for a review). The external medium could be either a precursor wind from the GRB progenitor (Chevalier & Li che) or the interstellar medium (ISM) of the host galaxy (Waxman wax). The interaction between the fireball and this ambient medium produces a shock that accelerates electrons and gives them a power-law distribution of ultra-relativistic energies, $N(\gamma) \propto \gamma^{-p}$, where $p$ is the electron energy index. This leads to the production of synchrotron emission where the flux of the afterglow can be described by a power-law decline in time and frequency, $F \propto t^{-\alpha} \nu^{-\beta}$ (Sari, Piran & Narayan sari98). The decay rate, $\alpha$, depends on the nature of the fireball and also on the density structure of the ambient medium. Light curves from observed afterglows typically have an initial decay index of $\alpha_1 \sim -1$, which often steepens 1–3 days after the GRB to $\alpha_2 \sim -2$ or even steeper (e.g. Fig. 4 in Andersen et al. andersen).

The GRB 011211 $R$-band light curve, presented by Holland et al. (holland2, hereafter H02), showed the OA decaying as a power-law with a slope of $\alpha = -0.83 \pm 0.04$ for the first $\sim 2$ days after the burst at which
time there was evidence for a break. Reeves et al. (reeves, hereafter R02) found that the X-rays emitted in the wake of GRB 011211 originated in an extremely hot gas outflowing from the GRB progenitor at $\sim 0.1c$, and that this gas was highly enriched with the by-products of a supernova explosion.

In this paper we present photometry of the OA of GRB 011211, taken between $\sim 0.6$ and $\sim 30$ days after the burst occurred. We explore the properties of the X-ray light curve, observed between $\sim 0.5$ and $\sim 0.85$ days from the onset of the burst. We model the afterglow data and conclude that the most likely model is a jet expanding into an external environment with a constant mean density. We also analyse HST/STIS images in order to derive the photometric properties of the host galaxy.

The organization of this paper is as follows. The optical and near-infrared (NIR) observations are presented in Sect. obs.sec. In Sect. hst.sec we analyze HST/STIS images of the OA and the host galaxy. In Sects. optical.sec and xray.sec we investigate the optical and X-ray light curves. The spectral energy distribution (SED) of the afterglow along with the derived extinction is discussed in Sect. sed.sec. We use the derived properties of the OA in Sect. models.sec to compare our results with afterglow models. Finally, Sect. dis.sec summarises the main results. Throughout this paper, we adopt a Hubble constant of $H_0 = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$ and assume $\Omega_m = 0.3$ and $\Omega_\Lambda = 0.7$. Ground-based observations obs.sec GRB 011211 was detected by the Italian/Dutch satellite BeppoSAX on 2001 Dec 11.7982 UT. A 5 radius error circle was circulated via the GRB Coordinate Network (GCN) http://gcn.gsfc.nasa.gov/gcn/.4 hours after the burst (Gandolfi gandolfia). Less than 2 hours later the error radius was refined to only 2 (Gandolfi gandolphi). This X-ray rich GRB had a duration of approximately 270 s, making it one of the longest duration bursts observed by BeppoSAX and thus placing it firmly in the “long-duration” burst category.

figure 3259f1.ps An R-band image of the GRB 011211 optical afterglow. The position of the optical afterglow is marked with a small square. H used to transform the relative photometry onto the standard system. The photometric properties of these stars are given in Table 3259f2.