Dust reddening and extinction curves towards Gamma-Ray Bursts at z > 4 (A&A subm.)

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Scientific Context

During the first Gyr after the Big Bang, AGB stars had not enough time to form in high numbers, and the production and composition of dust in the early universe is thus an open question. In theory, most of the dust could have been produced in the expanded shells of supernova (SN) remnants or by subsequent grain growth in the ISM. High redshift GRB afterglows can be used as back-ground sources to measure dust column densities and test extinction curves along their host galaxies line-of-sight. The locally measured extinction curves towards the SMC, LMC and the MW are plotted Fig. 1, as well as an extinction curve proposed by Todini & Ferrera (2001) and Maiolino et al. (2006) for dust produced purley from SN.

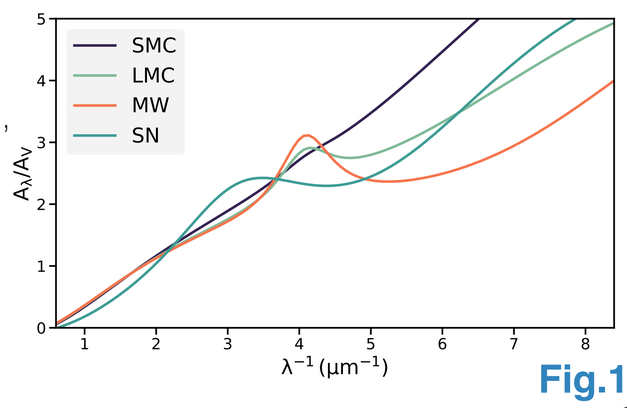

Fig.1

The GRB Sample

We present and analyze GROND and XRT observations of 24 GRBs at z > 4, from which 22 (+ data collected from the literatiure) were used to **derive the intrinsic visual dust extincton A_V and to test if an SN-like dust exintinction curve is required for for some of the bursts.**

In Fig. 2 we plot a histogram for all GRBs with a redshift estimate (complete until Jan. 2017). 40 of these GRBs are at z > 4.0, from which 24 were observed with GROND.

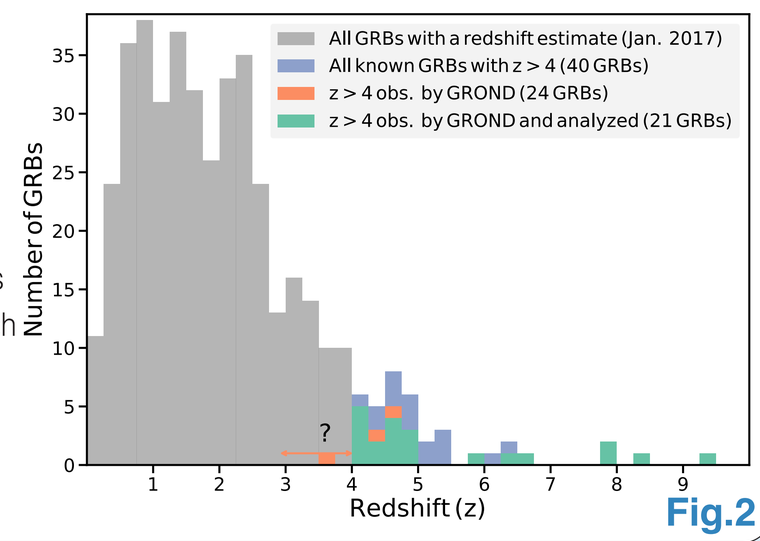

Fig.2

GRB 100905A at z_{ph} = 7.9

For the first time we also present the GROND data and a photometric redshift for GRB100905A. **With z_{ph} = 7.9, GRB 100905A belongs to the four most distant burst observed to date.** (The light-curve and GROND SED are shown in Fig. 3 & 4). The light-curve was modeled, in order to flux normalize the NIR/optical and X-ray spectra extracted from the gray shaded time-intervals to a common reference time.

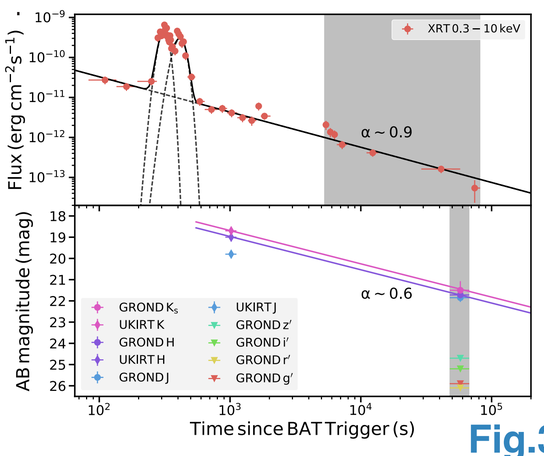

Fig.3

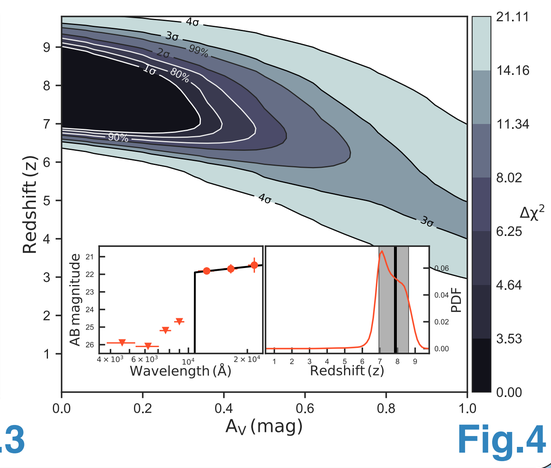

Fig.4

SED Fitting / Results

Similar to GRB100905A, we created and fitted all broadband SEDs in XSPEC with the local as well as the SN-type dust extinction curves. (Fig. 5 is showing the best-fit local ext. curves). **In contrast to samples at lower redshift, we find that all GRBs are only behind small host intrinsic dust column densities (A_V < 0.5 mag, see Fig. 6)**

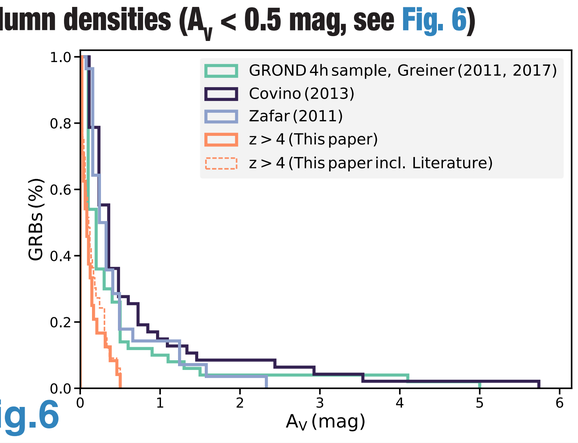

Fig.6

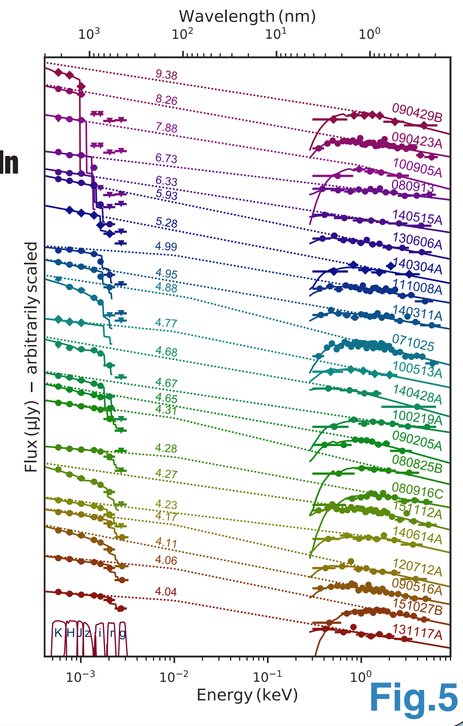

Fig.5

The SN-like dust extinction curve?

The SN-like dust extinction curve generally also provides a good fit to the GRBs (see Fig. 7), but only for two of the bursts the result is actually in better agreement with the data. Although better fit with the SMC extinction law, GRB 071025 is also consistent with the SN extinction curve, in accordance with the previous claim from Perley et al. (2010) and Jang et al. (2011).

However, since all SEDs are consistent with the locally measured extinction curves, we conclude that there is no need to assume drastically different dust properties at z > 4.

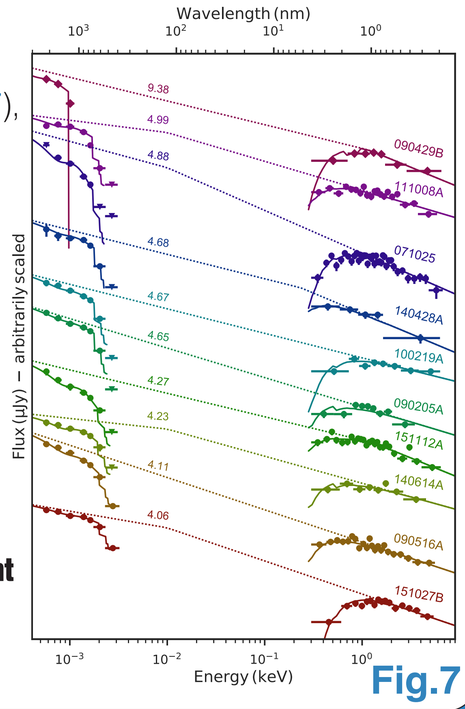

Fig.7

Less dust at z > 4!

Although the sample is partly biased against highly extinguished GRBs, an analysis of the GROND detection threshold and results from a Monte-Carlo simulation indicate that **GRB host galaxies at z > 4 are less dusty than at z ~ 2**. In Fig. 8 we show our A_V measurements compared to samples at lower redshift. The dashed lines represent GROND detection thresholds for three of the bursts.

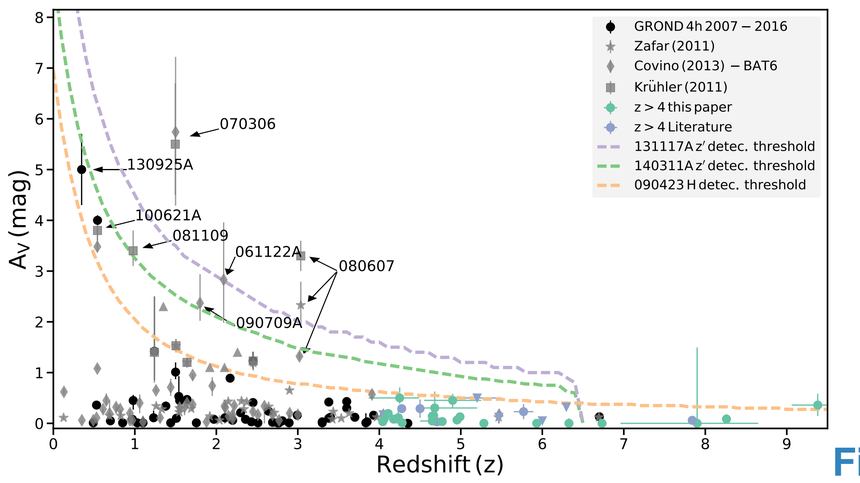

Fig.8

30 second summary

We create and fit broadband SEDs of 22 GRBs in order to derive the host intrinsic visual extinction A_V and to test extinction curves at z > 4.

We find that in contrast to samples at lower redshift, all bursts are only behind small dust column densities ($A_V < 0.5$ mag). Also, all SEDs can be fitted with locally measured extinction curves.

From the analysis of the GROND detection thresholds and the results of a Monte-Carlo Simulation, we conclude that **GRB host galaxies at z > 4 are less dusty than at z ~ 2.**