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Inflow of atomic gas fuelling star formation

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Abstract. Gamma-ray burst host galaxies are deficient in molecular gas, and show anomalous metal-poor regions close to GRB positions. Using recent Australia Telescope Compact Array (ATCA) HI observations we show that they have substantial atomic gas reservoirs. This suggests that star formation in these galaxies may be fuelled by recent inflow of metal-poor atomic gas. While this process is debated, it can happen in low-metallicity gas near the onset of star formation because gas cooling (necessary for star formation) is faster than the HI-to-H_2 conversion.

Keywords. galaxies: ISM, galaxies: formation, gamma rays: bursts, radio lines: galaxies

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1. Introduction

Galaxy formation models require significant gas inflow from the intergalactic medium to fuel star formation (Schaye *et al.* 2010). Indeed the current gas reservoirs in many galaxies are too low to sustain star formation (e.g. Draine 2009). Filamentary structures suggesting gas inflow have only been detected for two galaxies (Martin *et al.* 2014; Turner *et al.* 2015), so most of what we know about gas inflow is based on indirect evidence (Sancisi *et al.* 2008). In particular, metal-poor regions in inner parts of galaxies suggest recent accretion of metal-poor gas (Cresci *et al.* 2010; Sánchez Almeida *et al.* 2014).

Long gamma-ray bursts (GRBs) are explosions of very massive stars (e.g. Hjorth *et al.* 2003), so they pinpoint locations of recent star formation, which is usually believed to be fuelled by molecular gas (H_2; Carilli & Walter 2013). However, GRB hosts were found to be deficient in molecular gas (Hatsukade *et al.* 2014; Stanway *et al.* 2015). Moreover, these galaxies often exhibit metal-poor regions close to the GRB positions (Christensen *et al.* 2008; Thöne *et al.* 2008, 2014; Levesque *et al.* 2011).

2. HI survey of gamma-ray burst hosts: evidence for recent gas inflow

These properties, together with large atomic gas (HI) masses reported in the first HI survey of GRB hosts (performed with ATCA; Michałowski *et al.* 2015) can be interpreted as a sign of recent metal-poor atomic gas inflow fuelling star formation giving rise to the GRB progenitor. Indeed, HI centroids are offsets towards the GRB locations, and in one case an optically dark HI object is present $\sim$ 20 kpc away from the GRB host, which can originate from inflowing gas. Moreover, the concentration of HI close to one GRB position was confirmed by follow-up observations of Arabsalmani *et al.* (2015).

Star formation fuelled by atomic gas can happen in recently-acquired metal-poor gas (even if the metallicity in other parts of a galaxy is higher), because gas cooling (necessary for star formation) is faster than the HI-to-H_2 conversion (Krumholz 2012). GRB sites would then be expected to be metal-poor but relatively dusty (due to rapid dust production), consistent with observations (Hatsukade *et al.* 2014; Michałowski *et al.* 2014).

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