Gravity drives the evolution of infrared dark hubs: JVLA observations of SDC13

Gwenllian Williams & Nicolas Peretto

gmw8@st-andrews.ac.uk
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1. Introduction

Interstellar filaments represent a key archetypal stage in star formation. As they become gravitationally unstable, the densest filaments fragment into cores [1], the direct progenitors of stars. Yet questions remain regarding the link between filament, core, and star formation. Reservoirs of cold molecular gas called Infrared Dark Clouds (IRDCs), with no significant evolved star formation, help shed light on this as they preserve the mostly pristine initial fingerprints of star formation before destructive star formation processes such as feedback destroy the parent cloud.

We present a new high angular resolution & high spectral resolution interferometric study of the SDC13 hub filament IRDC system down to spatial scales of ~0.07pc, capable of probing the scales pertaining to the missing link between filaments and cores.

2. The SDC13 hub

SDC13 is a hub IRDC system of 4 parsec-long filaments located 3.6kpc away, containing 1000$M_\odot$ of material (Figure 1) [2] [3]. Previous single-dish data at 27'' resolution (~0.5pc scales) revealed a broad velocity width of ~2km/s at the hub centre, interpreted as the convergence of multiple gas flows along the filaments. However, the poor spatial resolution was not enough to study the fine scale link between filament and core formation. Hence, using the JVLA interferometer (combined with the GBT single dish) we obtained new 4'' resolution data (~0.07pc scales), a 7-fold improvement [4].

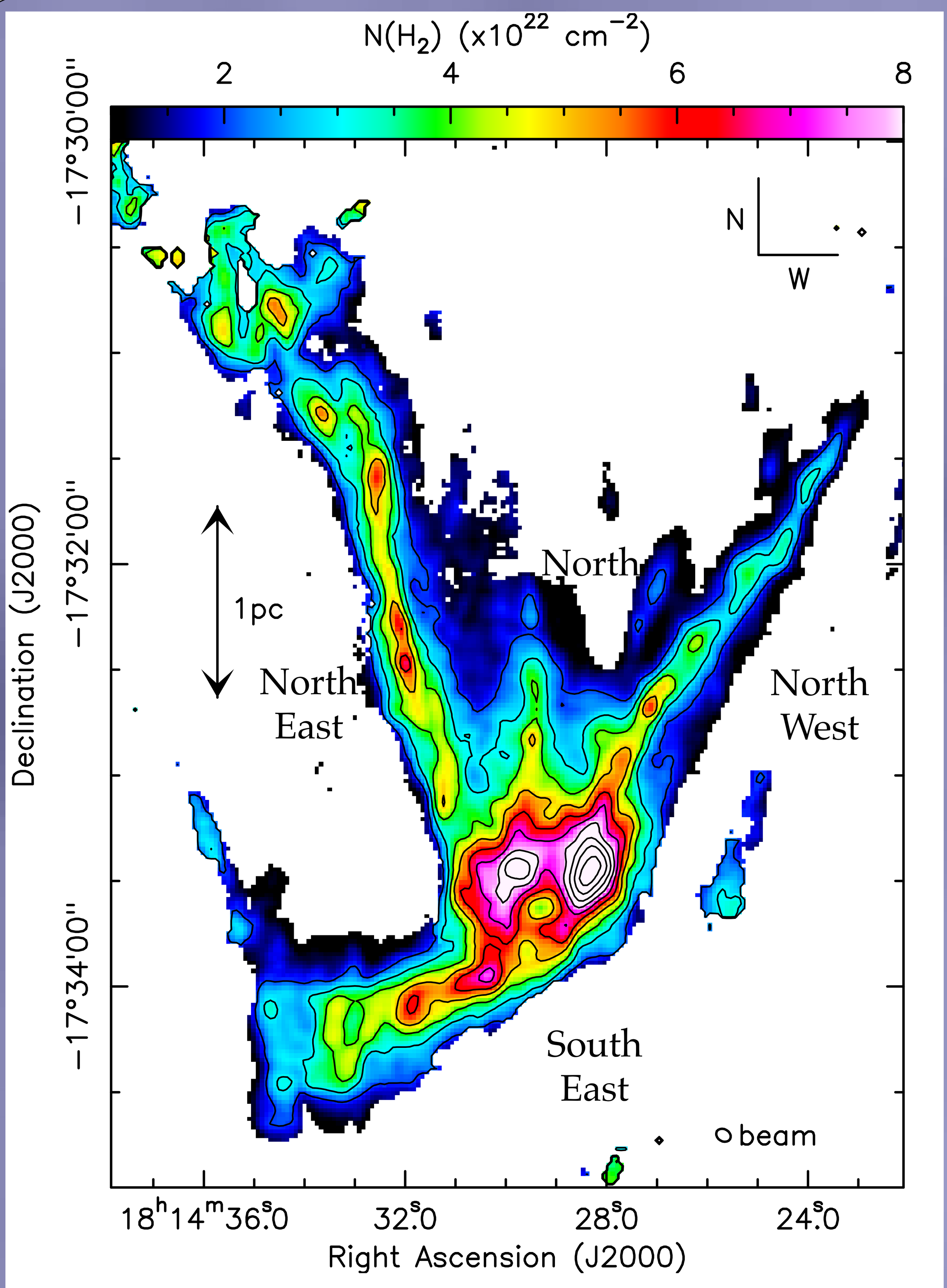

Figure 1. H_2 Column density across the 5'x5' extent of SDC13. Filament names are labelled.

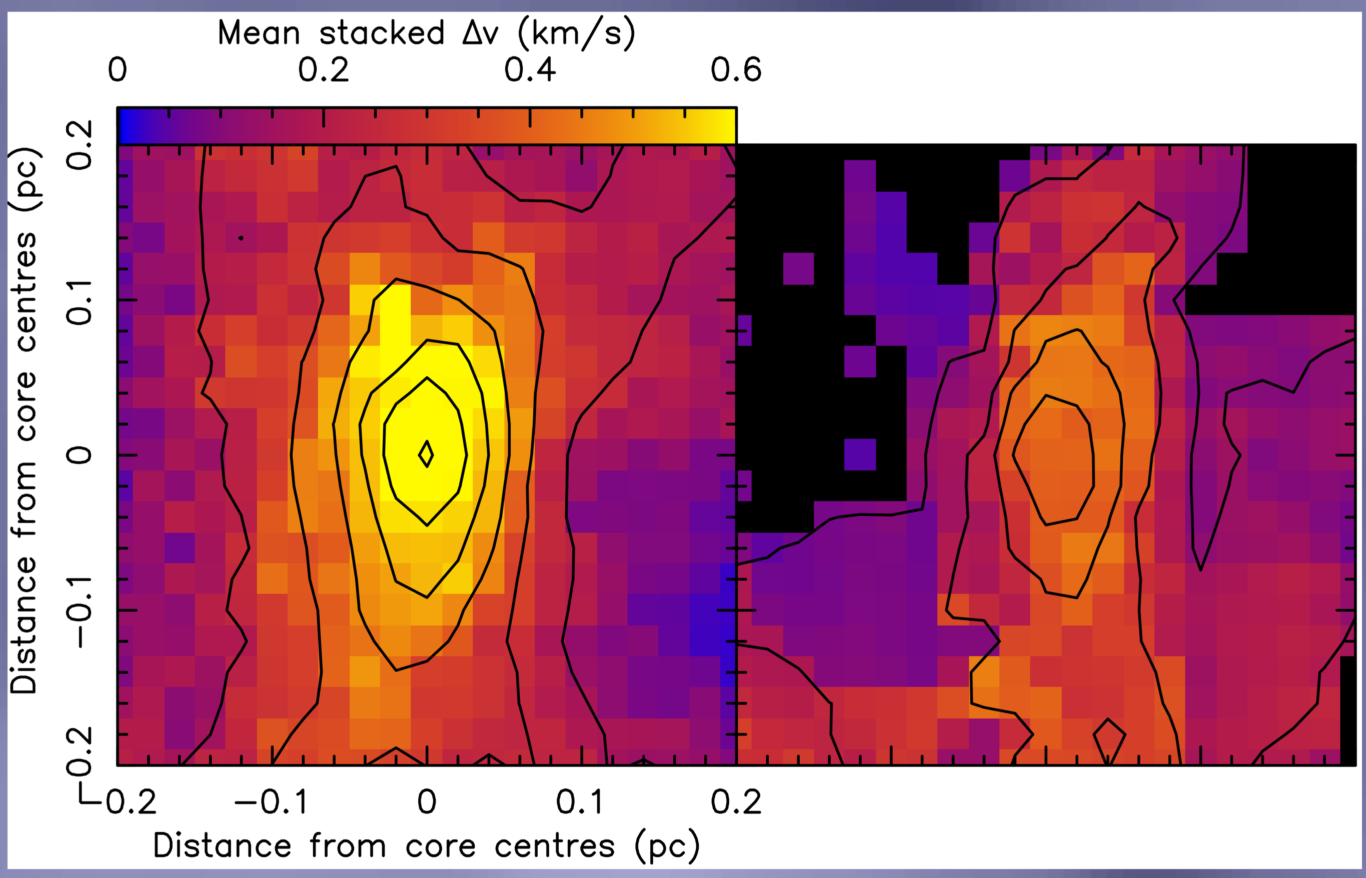

Figure 2. Stacked visual representation of the average velocity width at starless core positions with peaks (left) and without peaks (right). Overplotted mean stacked column density contours.

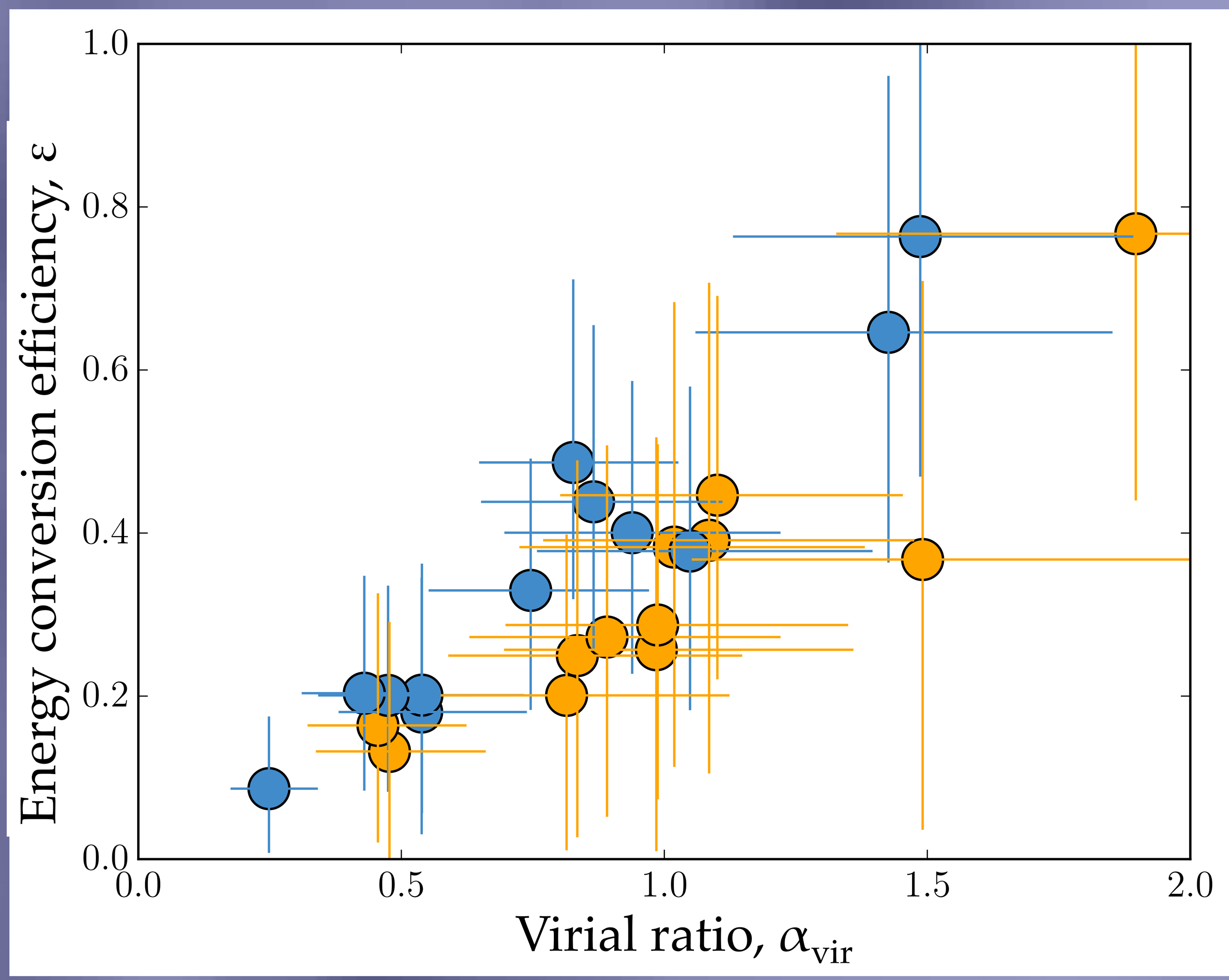

Figure 3. Observed virial ratio plotted against the energy conversion efficiency of GPE into KE, for the combined JVLA+GBT data (blue) and the JVLA-only data (orange).

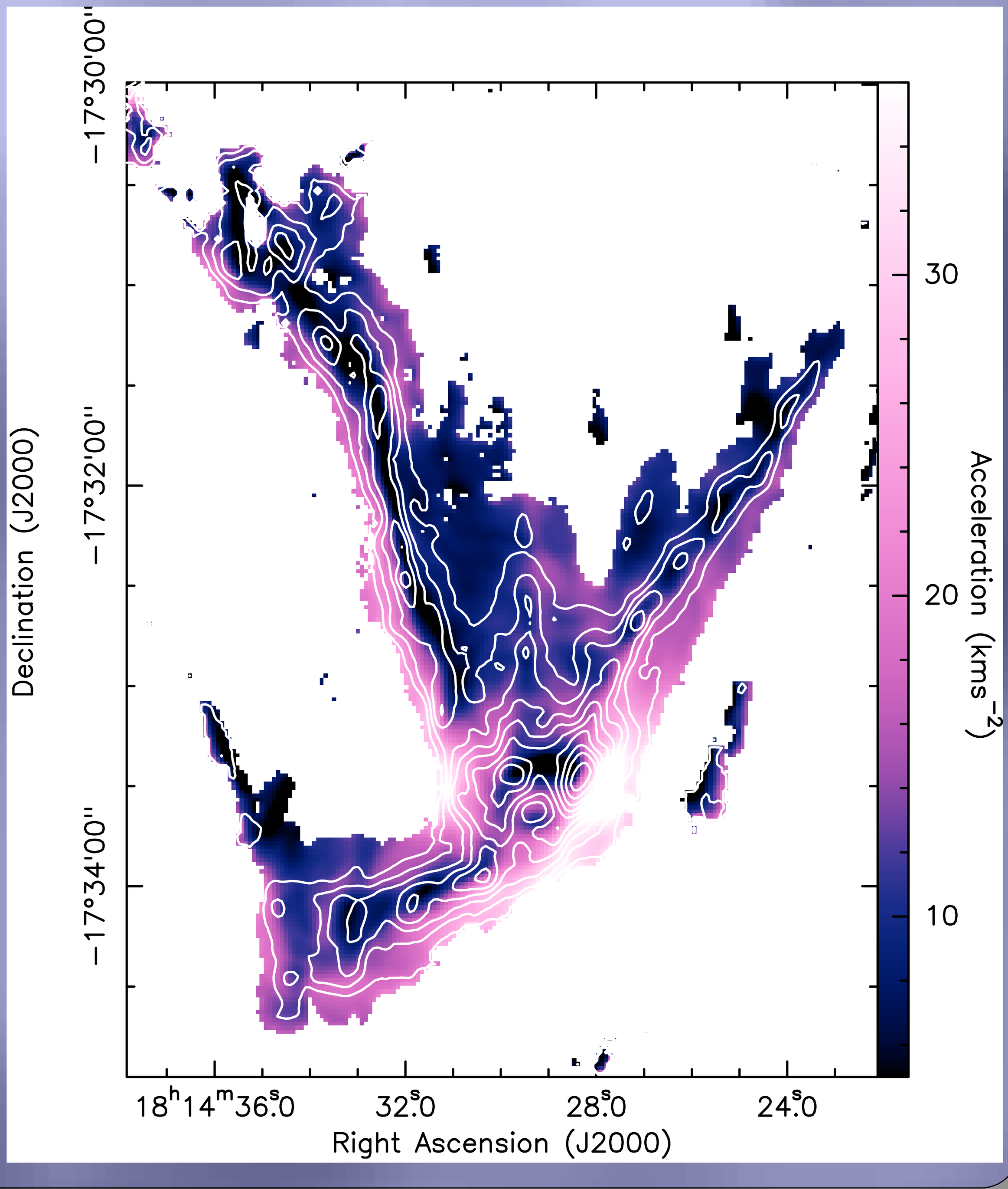

Figure 4. The acceleration due to gravity at each pixel, where the mass of each pixel was calculated from the H_2 column density of Figure 1 (white contours).

3. Results

Contrary to that seen in nearby star forming regions [5], two-thirds of starless cores in SDC13 show **peaked velocity width** at their centres. We believe these are signatures of the fragmentation process itself, indicating the conversion of gravitational potential energy to kinetic energy during gas accretion into cores. This **local increase of dynamic pressure** may prevent further fragmentation and contribute to **super-Jeans core formation**, and hence the **formation of intermediate-mass stars**. Furthermore, we calculate the mean energy conversion efficiency from GPE into KE of ε~40% in these starless cores, larger than theoretically published.

Calculating the acceleration due to gravity everywhere in the cloud, we notice the **largest acceleration gradient** corresponds to the **largest core at the hub centre**, even when a constant mass across the entire cloud is used. This reveals the **importance of the hub morphology** itself in the accumulation of material, rendering the **hub centre a privileged location** for the most massive stars.

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References: [1] André et al. 2010, AAP, 518, L102. [2] Peretto & Fuller 2009, AAP, 505, 405. [3] Peretto et al. 2014, A&A, 561, A83. [4] Williams et al. 2018, A&A, in press, arXiv: 1801.07253 [5] Pineda et al. 2010, ApJL, 712, L116. Background: SDC13 Spitzer 8μm map [3].