Formation, evolution, and survival of massive star clusters
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Massive cold cloud clusters

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Abstract. The all-sky Planck catalogue of Galactic Cold Clumps (PGCC) allows an almost unbiased study of the early phases of star-formation in our Galaxy. Several thousand of the clumps have also distance estimates allowing a determination of mass and density. The nature of Planck cold clumps varies from IRDCs to tiny nearby cold clouds with masses ranging from one to several tens of thousands solar masses. Some of the clumps are embedded in GMCs, others are isolated. Some are close or even very close to OB associations, while others lay far from any UV luminous objects. The small scale clustering of nearby PGCCs was studied with the improved Minimum Spanning Tree (MST) method identifying groups in 3D space, locating also massive cold cloud clusters eg. PGCCMST G210.6-19.5 in LDN 1641.

Keywords. ISM: clouds; ISM: individual LDN 1641, Orion A; ISM: magnetic fields

1. MST analysis of PGCCs

The Planck† survey (Planck Collaboration 2011) provided the first all sky catalogue of cold ISM objects, the Planck Catalogue of Galactic Cold Clumps, (PGCC, Planck Collaboration 2015a) with 13188 Galactic sources. Reliable distance estimates and high quality flux densities were obtained for 3911 PGCCs. We have used the Minimal Spanning Tree method (MST, Cartwright & Whitworth 2004) to identify PGCC clusters. The parameters of MST clusters with more than three members were defined following Cartwright & Whitworth, (2004) and Schmeja & Klessen (2006): cluster radius, R_c, is the distance between the mean position of all cluster members and the most distant sources; convex hull radius, R_h, the radius of a circle with an area equal to the area of the convex hull of the cluster members; elongation measure, $\xi = R_c/R_h$. See an example in Figure 1.

2. Results

Our MST analysis located 137 clusters when applied to the 870 PGCCs in Taurus, Perseus, Auriga and Orion, at a distance of 140-420 pc. LDN 1641 (Orion A main ridge) hosts the most massive cluster. It is located between OriKL and L1641S, and it includes L1641N, NGC1999 and L1641C, see Figure 1. It has a total mass of 1400 $M_\odot$ in 22 PGCCs including PGCC G212.10-19.15, the second most massive PGCC (300 $M_\odot$) within 1 kpc. The cluster members have a median temperature of 12.9 K and a median mass of 48 $M_\odot$.

† http://www.esa.int/Planck

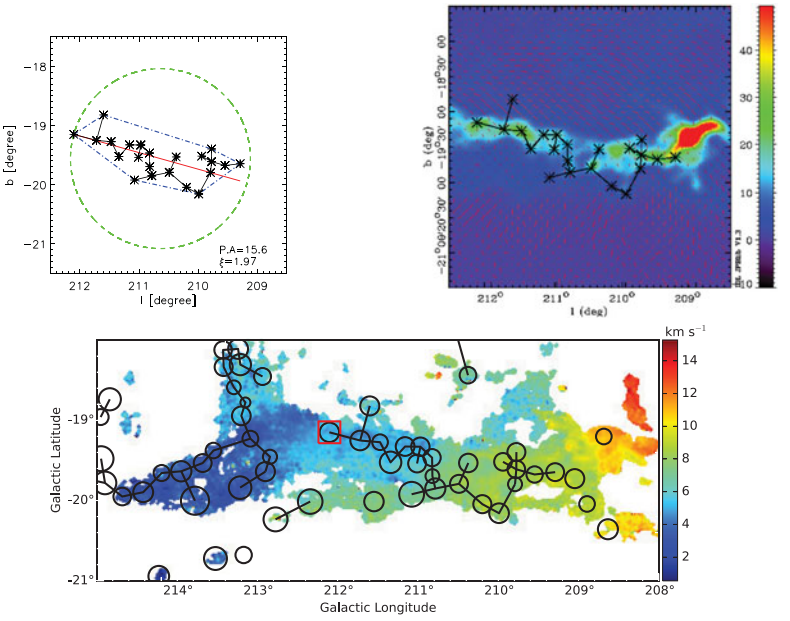

Figure 1. The PGCCMST G210.6-19.5 cluster in L1641, PGCC clumps with reliable distance and flux estimations (marked with asterisks in the top, and circles in the bottom figures), and MST branches (black solid lines). **Top left:** Convex hull (blue dashed-dotted line), cluster elongation direction (red line across), radius (indicated by green dashed circle), position angle and elongation measure are written. **Top right:** B field vectors and MST cluster overlaid on the 353GHz intensity map. **Bottom:** First moment map of the ^{13}CO(2-1) line (Osaka-1.85m survey, Nishimura *et al.* 2015) with PGCC clumps overlaid (circle, size = effective radius). Red square: PGCC G212.10-19.15 the most massive clump. Neighboring MST clusters are also shown.

The magnetic field is perpendicular to the high column density filamentary structure, in good agreement with Planck Collaboration (2015b), i.e. that the B field progressively rotates orthogonal to filaments at higher column densities.

The cluster is divided into two sub-clusters based on the velocity distribution, as seen in Figure 1, the 1st moment map of ^{13}CO(2-1) (Osaka-1.85m Orion Survey, Nishimura *et al.* 2015). The sub-cluster of 9 PGCCs with $b > 210°$ still is the most massive PGCC group in the nearby star forming regions with a total mass of ∼620 $M_\odot$.

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