The Milky Way atlas for linear filaments

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ABSTRACT

Context. Filamentary structure is important for the ISM and star formation. Galactic distribution of filaments may regulate the star formation rate in the Milky Way. However, interstellar filaments are intrinsically complex, making them difficult to study quantitatively.

Aims. Here we focus on linear filaments, the simplest morphology that can be treated as building blocks of any filamentary structure.

Methods. We present the first catalog of 42 straight-line filaments across the full Galactic plane, identified by clustering of far-IR Herschel HiGAL clumps in position–position–velocity space. We investigated the dynamics along the filaments using molecular line cubes, compared the filaments with Galactic spiral arms, and compared ambient magnetic fields with the filaments’ orientation.

Results. The selected filaments show extreme linearity (>10), aspect ratio (7–48), and velocity coherence over a length of 3–40 pc (mostly >10 pc). About one-third of them are associated with spiral arms, but only one is located in the arm center (known as the “skeleton” of the Milky Way). A few of them extend perpendicular to the Galactic plane, and none is located in the Central Molecular Zone (CMZ) near the Galactic center. Along the filaments, prevalent periodic oscillation (both in velocity and density) is consistent with gas flows channeled by the filaments and feeding the clumps that harbor diverse star formation activity. No correlation is found between the filament orientations with Planck measured global magnetic field lines.

Conclusions. This work highlights some of the fundamental properties of molecular filaments and provides a golden sample for follow-up studies on star formation, ISM structure, and Milky Way structure.

Key words. stars: formation – ISM: clouds – ISM: magnetic fields – ISM: structure – Galaxy: structure

1. Introduction

Filamentary structure is the dominant morphology of the interstellar medium (ISM), and molecular filaments can play an important role in star formation (Hacar et al. 2023). The Galactic distribution of filaments may regulate the global star formation rate in the Milky Way. The largest filaments can map out the skeleton (or “bones”) of the Milky Way in spiral arms (Wang et al. 2015; Zucker et al. 2015; Vallée 2016). However, the inherent complexity and hierarchy of molecular filaments make it challenging to characterize the structure and dynamics important for star formation. Traditionally, to study star formation, maps of molecular clouds are often decomposed into cores (e.g., Williams et al. 1994; Berry 2015), and in recent years also into filaments (e.g., Men’shchikov 2013; Koch & Rosolowsky 2015). While spherical cores, by definition, are simple in morphology, and are thus relatively easy to treat theoretically, filaments are not. More critically, the community has not yet reached a consensus on the definition of what a filament is; this has resulted in a wide range of filaments reported in the literature, from simple filaments of linear L-shape, C-shape, and S-shape to a network of filamentary structure of X-shape (Wang et al. 2015) and hub-filament systems (Myers 2010; Zhou et al. 2022). A meaningful comparison of these filaments is thus difficult because they are intrinsically different entities (cf. Zucker et al. 2018).

We proposed a physically driven definition of filaments (Wang et al. 2016) inspired by the “sausage” instability of a gaseous cylinder (Chandrasekhar & Fermi 1953). Under self-gravity, a supercritical filament radially collapses and fragments into a string of equally spaced clumps. Built on this picture, we developed a customized minimum spanning tree (MST) algorithm to identify filaments by clustering clumps in position-position-velocity (PPV) space. We applied this to PPV clump catalogs decomposed from three Galactic plane surveys: the Bolocam Galactic Plane Survey (BGPS), the APEX Telescope Large Area Survey of the Galaxy (ATLASGAL), and the Structure, Excitation, and Dynamics of the Inner Galactic Interstellar Medium (SEDIGISM) survey (Wang et al. 2016; Ge & Wang 2022; Ge et al. 2023, hereafter Papers I, II, and III, respectively). However, these surveys cover only a portion of the Galactic plane. More importantly, these filaments and others reported in the literature to date have a large variety of linearity and morphology classes. Such limitations prevent a further characterization of the fundamental common properties of filaments. A full Galactic plane census of the same entities is highly demanded.

Here, we identify and characterize the most collimated straight-line filaments across the full Galactic plane, using data from the Herschel HiGAL survey. Among all the morphology types (Wang et al. 2015), linear filaments are the simplest, and can be treated as unit filaments, or building blocks of more complicated filamentary structures. The physical characterization of...
these units can pave the way toward a unified understanding of filaments (Liu et al. 2018; Zucker et al. 2018). For example, several questions arise, including how long a straight-line filament can extend in our Galaxy, how they distribute in the Galaxy and map out the spiral arms, and the role they play in star formation. The answers to these questions are crucial for a quantitative understanding of star formation in our Galaxy and in other galaxies as interferometric observations are routinely resolving the largest filaments in nearby galaxies (Wang et al. 2015). This work provides a key step forward.

2. Data and method

The Herschel infrared Galactic Plane Survey (HiGAL) mapped the entire Galactic plane at five bands: 70, 160, 250, 350, and 500 μm (Molinari et al. 2010, 2016). A band-merged catalog has been released, containing a total of ~150 k sources with physical properties determined for most sources (Elia et al. 2017, 2021). Of the ~150 k sources, ~126 k sources have radial velocity resolved using literature data. These sources form by far the deepest, largest, and most uniform PPV catalog of dust clumps across the entire Galactic plane, excellent for finding filaments using our MST method. Elia et al. (2021) assigned HiGAL clumps into high-reliable and low-reliable catalogs, based on the quality of spectral energy distribution (SED) fitting. Here we merged the two catalogs as we are more interested in PPV information to begin with. The HiGAL sources have an average diameter of 25" and 0.6 pc. For simplicity, we refer them as clumps in this Letter, although their physical scales can be up to few parsecs for sources at large distances.

We searched for filaments using the MST method following Papers I, II, III. In brief, any two clumps in the Elia et al. (2021) catalog are connected only if they are close enough in position (spatial separation Δs < 0.06") and in velocity (Δv < 2 km s⁻¹). These criteria result from robust tests (see details in Papers I, II, and III). This results to ~3.4k MST trees containing at least five clumps. A strict linearity of >10 is applied to select the most prominent straight-line filaments. Linearity is defined as the ratio between the spread of clumps along the long and short axes (Papers I, II, Fig. A.2). The selection results in 42 linear and velocity-coherent (LV) filaments. Most of them are new identifications, and only six of them are associated with previously known filaments (Table A.1). For example, F36 and F7 are the central and linear part of the well-known S-shaped Nessie filament (Jackson et al. 2010; Wang et al. 2015), and the X-shaped Herschel cold filament CFG26 (Wang et al. 2015).

Thanks to HiGAL's full coverage of the Galactic plane, and the >10 times larger number of PPV clumps compared to previous PPV catalogs used in Papers I, II, and III, we were able to extract an atlas of linear filaments in the Milky Way disk. Unlike in Papers I, II, and III, here we did not put a length cut (>10 pc for large-scale filaments), but strictly limited the linearity to select straight-line filaments. They are the building blocks of more complex filamentary structure, and it is of great interest to investigate their properties.

After finding the filaments (as strings of clumps), we used properties of the HiGAL clumps (Elia et al. 2021) as the basis to characterize the filaments (Sects. 3.1 and 3.5). These include clump position, velocity, distance, diameter, mass, luminosity, temperature, association with 70μm point source, and evolutionary stages (starless, prestellar, and protostellar). A Galactic spiral arm model is compared to the filaments (Sect. 3.2). Molecular line maps are retrieved from public surveys to analyze the dynamics (Sects. 3.3 and 3.4). Dust polarization maps from the Planck are used to derive global magnetic fields of the filaments (Sect. 3.6).

It should be noted that our MST approach is different from other automated identifications that directly decompose continuum images (e.g., Schisano et al. 2020; Li et al. 2016), which resulted orders of magnitude more filaments, and did not use velocity information in identification. Our approach uses a uniform PPV catalog as input, and can have a physically driven criteria for filaments. In comparison, Li et al. (2016) identified 517 ATLASGAL filaments merely in the inner Galactic plane; only three have overlaps with our filaments (Table A.1). Schisano et al. (2020) identified 32 059 candidate filaments using HiGAL images. Generally, they are not the same kind of features as our filaments.

3. Results and discussion

3.1. Global properties

Figures 1a,b present example filaments in far-IR. Herschel 250μm emission in red provides a rough proxy for column density, and the 70μm emission in cyan highlights point sources of embedded young stellar objects, indicative of star formation. The white lines outline the filaments end to end. The 42 filaments can be divided into four categories of star formation activity: Quiescent (no 70 μm point source), Flower (star formation developed at one tip, or head-tail), Central (star formation developed in central clumps), and Necklace (star formation developed in almost all clumps). Evolution and dynamic effects, including edge collapse (Yuan et al. 2020; Bhadari et al. 2022) likely play a role in shaping the appearance of the filaments, which deserve further study.

Table A.1 lists physical properties of the filaments, and Fig. A.1 illustrates the distribution of some parameters. Distance is determined from the distances of the clumps in a filament. For most filaments, the clumps have consistent distances reported in Elia et al. (2021). In a few cases (F1, 9, 39, 41, 42) the clump distances are spread and contain near and far distances; additional judgements are made based on the infrared extinction or emission to adopt either a near or a far distance for a filament. Clumps in three filaments (F13, 22, 30) have no available distance; we compute distances using the parallax-based Bayesian distance estimator provided by Reid et al. (2019, 2016). No obvious selection effect is seen in the distance histogram (Fig. A.1), which shows a broad range of 1.2–16.3 kpc, and a weak peak at 4–5 kpc, corresponding to the Galactic molecular ring (Jackson et al. 2006). After determining the filament distance, related clump parameters in Elia et al. (2021) are scaled accordingly to computer filament properties.

Originating from selection, the filaments show remarkable linearity and aspect ratios. The filament length is measured by the sum of the MST edges (thus following the curvature), and adding sizes of the two edge clumps to account for the actual length of the filament. This edge length is on average only 3% (and up to 12%) larger than the end-to-end length by simply connecting the two clumps at the tips with a straight line (shown in Fig. 1). The small curvature provides another measure of the extreme linearity resulted from the selection criteria. Of the 42 filaments, 28 are longer than 10 pc, satisfying the large-scale filaments in Papers I, II, and III. The aspect ratios (7–48) are among the highest reported in the literature.

A lower limit of filament mass (5 × 10² to 5 × 10⁴ M☉) is given by the sum of clump masses. According to Paper II, this lower limit is typically 36% of the total filament mass. A global
velocity gradient is determined by a linear fit to the \((l_i, v_i)\) plot, where \(l_i\) is the length along the filament, and \(v_i\) the LSR velocity of the \(i\)th clump in a filament. We note that the slope (velocity gradient) of the fitted lines can be positive or negative, depending on the orientation.

Mass, luminosity, and luminosity-to-mass ratio are among the sharpest distributions (Kurtosis \(K = 12, 22.5, 8\), Table A.1). However, they are dominated by a long tail at the right side consisting of only three large values. If these outliers are removed, the distributions would be quite flat. Aspect ratio, number of clumps, and angular length also show sharp distributions \((K = 7.5, 10, 10)\) with no obvious outliers.

### 3.2. Galactic distribution and association with spiral arms

The 42 linear filaments are located in all four Galactic quadrants, concentrating in quadrants I (20 filaments) and IV (16 filaments), while quadrants II and III have only 2 and 5 filaments, respectively (Figs. A.1 and 2). Interestingly, no linear filaments are found near the Galactic center, in the Central Molecular Zone (CMZ, Lu et al. 2019), and at low longitudes of \(-8^\circ < l < 10^\circ\). The averaged Galactic longitude and latitude of the filaments are \((l, b) = (-8.92, -0.05)\) deg. Distributions of both \(l\) and \(b\) slightly skew toward the negative side (skewness \(S_l = -0.9, S_b = -0.2\)).

The \(l\) distribution is slightly more centrally peaked than normal distribution, and the \(b\) is flatter \((K_l = 0.5, K_b = -0.1)\). After taking distance into account, most filaments are found within the solar circle, with 31 in the inner Galaxy and 11 in the outer Galaxy (Fig. 2).

Figure A.1 shows that the filaments are concentrated on the Galactic mid-plane \((K_z = 4.1)\), most of which are within height \(|z| < 100\, \text{pc}; only seven of them are located at a greater height up to 320 pc. In contrast, the orientation of the filaments with respect to the Galactic mid-plane \((\theta)\) does not show obvious preference \((K_\theta = -1.5, S_\theta = 0)\); these well-defined filaments appear to be randomly oriented (cf. bimodal distribution in Ge et al. 2024). Notably, a few filaments extend perpendicular to the Galactic plane (e.g., F4 in Fig. 1). These properties are important to further understand the formation of these filaments (e.g., Feng et al. 2024; Zucker et al. 2019).

We compare the filaments to spiral arms following the criteria of Papers I, II, and III. We adopt the Taylor & Cordes (1993) spiral arm model because it is derived based on measurements in all four Galactic quadrants. More recent models do not have sufficient observations in the southern sky (Paper III). A filament is considered to be associated with a spiral arm when its LSR velocity is within \(\pm 5\, \text{km s}^{-1}\) of the spiral arms in the Galactic longitude-velocity tracks (Fig. 2). This results in 14 filaments.
associated with arms: 5 on Perseus, 4 on Sagittarius-Carina, 3 on Scutum-Centaurus, and 2 on the Norma-Outer Arm. We note that these 14 on-arm filaments have rather spread orientation angles (similar to the entire sample), with only 5 filaments having \( \theta \leq 30^\circ \) (i.e., running almost parallel to the mid-plane, after projection). Surprisingly, among these, only one (F36, the central part of Nessie) fulfills the additional criterion for a Galactic skeleton (i.e., lying in the center of mid-plane; \( |z| \leq 20 \) pc). Another four parallel filaments are offset higher to the mid-plane (\( |z| = 27–50 \) pc).

3.3. Velocity oscillation along filaments

Our sample of filaments represent a string of clumps semi-equally spaced along the filaments. This Necklace configuration is a natural result of the sausage instability (Chandrasekhar & Fermi 1953; Ostriker 1964; Fiege & Pudritz 2000). Once this configuration is formed, materials can flow along the filaments to feed the clumps, enhancing star formation activity therein. Fluctuations of velocity along filaments have been observed, consistent with mass flows (Hacar & Tafalla 2011; Zhang et al. 2015; Wang 2018; Henshaw et al. 2020).

Our unbiased sample provides an ideal test bed to investigate whether mass flows are common in filaments, and further revealing their properties. Of the 42 filaments, we were able to retrieve molecular line cubes for 20 filaments from public surveys (Jackson et al. 2006; Barnes et al. 2015; Umemoto et al. 2017; Schuller et al. 2017, 2021; Cubuk et al. 2023). These provide \(^{13}\)CO(1–0), \(^{12}\)CO(1–0), or \(^{13}\)CO(2–1) cubes that well resolve the filaments. Few other filaments are also covered by the surveys, but the data quality is insufficient for our following analysis. A position-velocity (PV) cut is extracted along the filaments by connecting the clumps. At a given position along the filament, the intensity weighted centroid velocity (moment 1) and dispersion (moment 2) are plotted in Fig. 1c.

All the 20 PV curves show some variation in velocity along the filaments, most of which appear to be semi-periodic. We first fit a global slope in the PV curve, and then perform periodicity analysis on the residual PV curve, following Wang (2018). For 19 of the 20 filaments, the periodicity analysis reveals one or two dominant periods \( (P_\text{d}) \). (The only exception is F12 with a weak peak of \(-4\) pc period.) In 11 filaments, the primary period closely matches \( P_{\text{d}} \), defined as the mean separation between the clumps. In the remaining eight filaments, the secondary period closely matches \( P_{\text{d}} \). So, in all cases but one, the PV curves are oscillating with either a primary or secondary period that closely matches \( P_{\text{d}} \). The averaged ratio \( P_{\text{d}}/P_{\text{cl}} \) is 1.0 ± 0.2. This is strikingly consistent with the model proposed by Hacar & Tafalla (2011), and strongly suggests that gas flows are channelled by these linear filaments, and are feeding the clumps. Each of the clumps are potential or ongoing sites for star or star cluster formation (Sect. 3.5). The global PV slope may represent net bulk gas motions from end to end of the filament, at a fitted rate of 0.0–0.35 km s\(^{-1}\) pc\(^{-1}\) (average 0.09 km s\(^{-1}\) pc\(^{-1}\)). Localized to the clumps, the velocity gradient is typically ten times higher, due to velocity oscillation (Fig. 1c).

3.4. High velocity-coherence

With no exception, all of the filaments show remarkable coherence in velocity. Along the full lengths up to nearly 40 pc, the velocity difference between the maximum and minimum velocities of all the clumps in a given filament is in the range 0.0–4.3 km s\(^{-1}\) (average 1.5 km s\(^{-1}\)). Normalized by length, this cor-

![Fig. 3. Cumulative distribution function (CDF) of plane of sky projected angles between the filaments and the ambient B-fields \( (\gamma_\theta) \). The blue dashed line shows the CDF of randomly distributed \( \gamma_{3D} \) values. The two black dotted lines show expected CDF for parallel \( (\gamma_{3D} = 0°–20°) \) and perpendicular distributions \( (\gamma_{3D} = 70°–90°) \).](image-url)
3.6. Filament orientation compared to magnetic fields

A geometrical configuration and alignment of the magnetic fields (hereafter B-fields) with filamentary structures could suggest the formation mechanisms of the filaments. Numerical and observational studies have shown that B-fields are preferably oriented either perpendicular or parallel to the filaments depending on the column density ($N_{\text{HI}}$) of the filaments and strength of B-field (e.g., Li et al. 2013; Soler 2019; Pillai et al. 2020; Jiao et al. 2024). The switch over from parallel to perpendicular orientation takes place at an $N_{\text{HI}}$ of $10^{21}$–$10^{22}$ cm$^{-2}$. Simulations of Soler & Hennebelle (2017) showed that the transition from a parallel to a perpendicular field orientation is introduced by anisotropic converging flows regulated by a dynamically important magnetic field on larger scales. It is thus important to explore the relative orientation of filaments in reference to the ambient B-fields.

Plane-of-sky orientation of B-fields toward our target filaments were estimated using the Planck 353 GHz (870 μm) dust continuum polarization observations. Stokes I, Q, U maps were extracted from the Planck Public Data Release 2 (Planck Collaboration I 2016; Planck Collaboration Int. XXXIII 2016). The maps have a pixel scale of ∼1′ and beam size of ∼5′. As our sole purpose of using Planck polarization data is obtaining the mean B-field orientation toward the filaments, the estimation of the position angles of the B-field was performed over a box with length equal to the length of the filament listed in Table A.1 and a width of 6′ around each filament. More technical details can be found in Baug et al. (2020).

A cumulative histogram of the relative 2D position angles between the filaments and the corresponding B-fields ($\gamma_{B}$) is shown in Fig. 3. We note that the calculated position angles are 2D projections of actual 3D angles. To examine the effect of projection on observed distribution of $\gamma_{B}$, we simulated about two million radially outward pairs of unit vectors randomly distributed on the surface of a sphere (see Stephens et al. 2017; Baug et al. 2020, for more details). Subsequently, we calculated their actual 3D angles ($\gamma_{3D}$) and also their 2D projection ($\gamma_{2D}$), assuming they are projected onto the y-z plane. These $\gamma_{2D}$ values could be considered as equivalent to the observed $\gamma_{B}$. Finally, we generated three different cumulative distribution functions (CDFs) of $\gamma_{2D}$ based on their actual 3D position angles: (1) parallel, with $\gamma_{3D}$ ranging between 0° and 20°; (2) perpendicular, with $\gamma_{3D}$ ranging between 70° and 90°; and (3) random, with $\gamma_{3D}$ for all possible angles ranging between 0° and 90°. Along with the cumulative histogram of $\gamma_{B}$, three CDFs are also shown in Fig. 3 for comparison.

No specific trend is noted in the cumulative histogram indicating toward a noncorrelation of filaments with the large-scale B-field orientation. This is broadly consistent with the Stratospheric Observatory for Infrared Astronomy (SOFIA) observations of filament G47 (Stephens et al. 2022). However, we caution that the polarization data could largely be affected by line-of-sight depolarization (Planck Collaboration Int. XXXIII 2016) due to unknown B-field structure within the volume sampled by the beam. Averaging of multiple emitting layers with different position angles along the line of sight may also lead to depolarization (Jones et al. 2015). We note that the angular resolution of the Planck data is comparable to the size of most of the filaments in our sample. The orientation of the B-fields could vary more at the scale (and subscale) of filaments than at larger scales, and the Planck data is incapable of resolving any such existing trends for the filaments in our sample. Dust polarization data at higher resolution are needed for a better comparison (e.g., Stephens et al. 2022).

4. Summary

We present the first catalog of 42 large-scale linear filaments across the full Galactic plane, and highlight some fundamental properties of them, including extreme linearity and velocity-coherence, velocity oscillation and filamentary gas flows, and diverse star formation activity. One-third of them are associated with the spiral arms and two-thirds are located inter-arm, but only one is located at the arm center (the Milky Way skeleton); none were found near the Galactic center and in the Central Molecular Zone. A few filaments extend perpendicular to the Galactic plane, while no obvious trend is found in the orientation of the full sample. The filaments also appear to be randomly oriented compared to ambient magnetic fields.

As linear filaments are building blocks for more complex filamentary structure, these properties are important for further studies toward a unified understanding of more general filamentary structure, their role in star formation, and the structure of the Milky Way ISM.

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Appendix A: Supporting materials

Table A.1 lists physical properties of the 42 filaments, and Figure A.1 shows distribution of some parameters. Figure A.2 presents the MST, and Figure A.3 illustrates the filaments in two-color far-IR views.

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Fig. A.1. Properties of the 42 linear filaments. Some parameters are plotted in logarithmic scale for better illustration at the long tails in distribution. The temperature histogram shows the minimum, maximum, and mean temperature of the clumps in filaments. Mass, mass/length ratio, and luminosity are lower limits (Sect. 3.1).
Fig. A.2. MST for F1 to F21. The red circles represent the position and size of the Herschel/HiGAL clumps, and the red segments are the MST edges connecting the clumps. The blue line marks the filament end-to-end.
Fig. A.2. continued. MST for F22 to F42.
Fig. A.3. Two-color view of the linear filaments F1 to F15. Herschel 250\(\mu\)m and 70\(\mu\)m are shown in red and cyan, respectively. The filament is marked by an end-to-end line in white.
Fig. A.3. continued for F16 to F30.
Fig. A.3. continued for F31 to F42.
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Table A.1. Physical properties of the filaments
Table A.1. Continued.

| ID | $l_1$ | $b_1$ | $l_2$ | $b_2$ | $v_{lsr}$ | $d$ | $Len.$ | $Le_{2e}$ | $Lmst$ | $v$ | Aspect | $\Delta v$ | Mass | Lum. | $L/M$ | $T$ | $N_{10}$ | $N_{14}$ | Linority | $\theta$ | $z$ | Arm | $P_v$ | $P_{cl}$ |
|----|-------|-------|-------|-------|----------|-----|-------|----------|-------|-----|--------|---------|------|------|-------|-----|--------|--------|----------|------|-----|-----|-------|
|    |       |       |       |       |          |     |       |          |       |     |        |         |      |      |       |     |        |        |          |      |     |     |       |
| Min | -177.97 | -1.67 | -124.9 | 1.2 | 0.062 | 2.8 | 2.8 | 0.2 | 7.2 | 0.0 | 0.00 | 4.8E+01 | 4.5E+00 | 0.03 | 8.6 | 0.0 | 50 | 10.1 | 1.9 | 320.5 | 1.1 | 0.5 |
| Max | 103.68 | 1.28 | 105.4 | 16.3 | 3.67 | 39.2 | 39.5 | 2.4 | 48.0 | 4.3 | 0.29 | 5.1E+04 | 1.4E+06 | 27.86 | 21.9 | 7.0 | 11.0 | 23.8 | 90.0 | 232.2 | 8.5 | 1.7 |
| Avg | -8.92 | -0.05 | 4.8 | 6.7 | 0.142 | 15.5 | 16.0 | 1.1 | 16.2 | 1.5 | 0.08 | 5.8E+03 | 6.6E+04 | 3.47 | 13.7 | 2.2 | 56 | 13.1 | 44.5 | 6.8 | 3.6 | 1.0 |
| Med | 1.40 | -0.05 | 9.9 | 5.4 | 0.135 | 13.9 | 14.1 | 1.0 | 15.3 | 1.5 | 0.07 | 2.1E+03 | 2.0E+01 | 0.69 | 12.8 | 2.0 | 50 | 12.2 | 51.2 | 18.0 | 2.8 | 1.0 |
| Std | 66.76 | 0.66 | 54.0 | 4.0 | 0.053 | 9.4 | 9.7 | 0.6 | 7.0 | 0.9 | 0.07 | 9.9E+03 | 2.6E+00 | 6.41 | 3.1 | 2.0 | 1.2 | 3.2 | 29.3 | 88.2 | 2.1 | 0.2 |

Notes. Col. (1) Assigned filament ID. Cols. (2-5) Galactic coordinates of the two end-to-end clumps. Statistics (last rows) are computed by converting $l$ to [-180, 180] deg. Col. (6) Mean LSR velocity of the clumps in a filament. Col. (7) Distance (Sect. 3.1). Cols. (8-9) End-to-end length, in angular and physical units. Col. (10) Curved length following the MST, i.e., connecting the clumps. Col. (11) Width, the diameter of the largest clump in the filament. Col. (12) Aspect ratio, length divided by width. Col. (13) Difference between the min. and max. velocity of the clumps in a filament. Col. (14) Slope by fitting clump velocity along the filament (Sect. 3.1). Statistics (last rows) are given for $|\text{Slope}|$. Cols. (15-16) Sum of clump mass/luminosity, which gives lower limit for filament mass/luminosity (Sect. 3.1). Col. (17) Luminosity/mass ratio. Col. (18) Mean dust temperature of the clumps. Col. (19-20) Number of 70$\mu$m sources, and number of HiGAL clumps. Col. (21) Linearity, as defined in Paper I and refined in Paper II (Sect. 2). Col. (22) Angle between filament and Galactic mid-plane. Col. (23) Height from the Galactic mid-plane. Col. (24) Associated spiral arm, if any. Col. (25) Velocity oscillation period determined from PV analysis (Sect. 3.3). Col. (26) Ratio of velocity period to density period (mean separation between clumps, Sect. 3.3).

The last rows list statistics of the parameters. Skewness ($S$) measures symmetry of a distribution. $S = 0$ means symmetric distribution, negative and positive $S$ mean asymmetric tails with lower and higher values around the mean, respectively. Kurtosis ($K$) measures how spread the distribution is compared to a normal distribution. A normal distribution has $K = 0$. $K > 0$ means the distribution is more centrally peaked than normal distribution, and $K < 0$ is flatter. Cross-match: Six filaments (F1, 3, 7, 35, 36, 40) (partially) overlap with previously known filaments. F1 is a small part of an X-shaped filament (F5 in Paper I and F7 in Paper II). F7 is part of the X-shaped Herschel cold filament CFG26 (Wang et al. 2015). F36 is the central and linear part of the well known S-shaped Nessie filament (Jackson et al. 2010; Wang et al. 2015). F40 is partly overlapped with F90 in Paper II. F3, F35, F36 are part of G014.478+0.736, G338.528+0.214, G338.680-0.455 in Li et al. (2016), respectively.