J plots: Detecting and classifying star-forming structures in the ISM

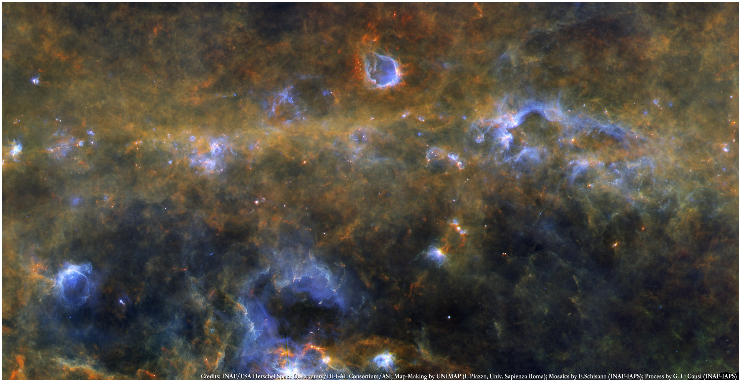
Sarah Jaffa

Star Formation Group
School of Physics and Astronomy
Cardiff University

Supervisor:
Prof. Anthony Whitworth,

EWASS, June 2017

Motivation



Hi-GAL survey, Via Lactea collaboration (S. Molinari+2010)

Filaments Compact objects

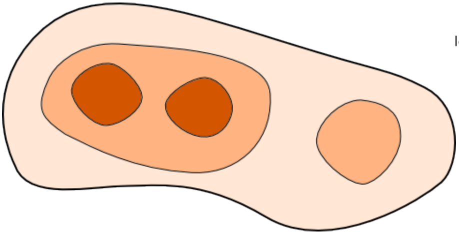
Rings Substructure

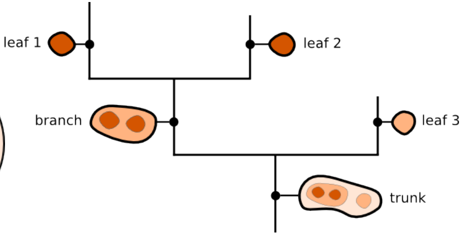
IDENTIFY
CLASSIFY
QUANTIFY

Image segmentation

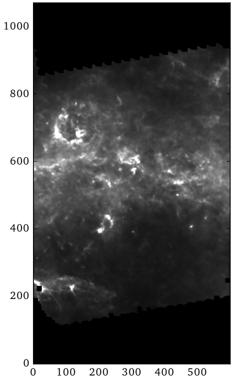
- Clouds, clumps or cores (SCIMES, ClumpFind, FellWalker, GaussClumps, CuTEx)
- Filaments (FilFinder, DisPerSE, getfilaments, Hessian matrix)
- Shells/bubbles (Citizen Science, machine learning)
- Shape free (Thresholding, dendrograms, friends-of-friends)

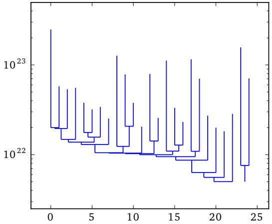
Dendrograms





Images from http://dendrograms.org/





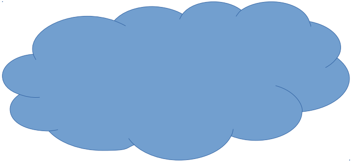
Herschel Hi-GAL column density map of a region around RCW 120.

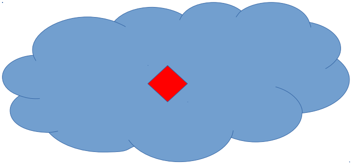
User defined parameters:

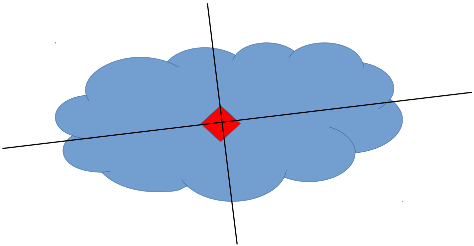
Background threshold

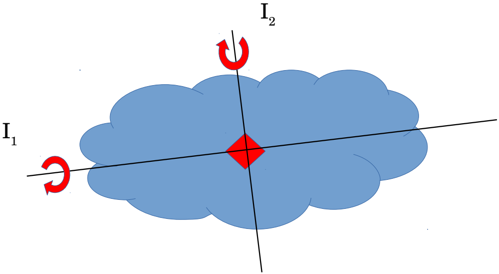
Minimum pixels

Minimum intensity difference



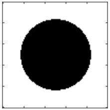




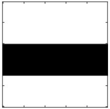


$$I = \int r^2 \, \mathrm{d}m$$

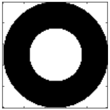
I_1, I_2 = first and second principal moments.



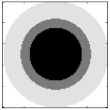
Flat disk: $I_1 = I_2 = \frac{Am}{4\pi}$



Filament: $I_1 > \frac{Am}{4\pi} > I_2$



Shell: $I_1 = I_2 < \frac{Am}{4\pi}$



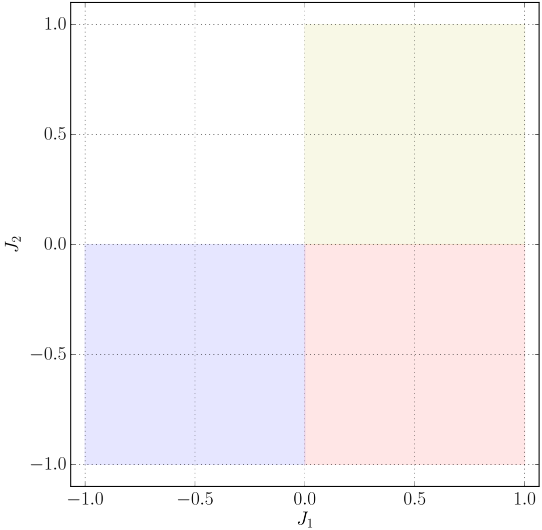
Centrally-concentrated: $I_1 = I_2 > \frac{Am}{4\pi}$

$A =$ area

$m =$ total mass

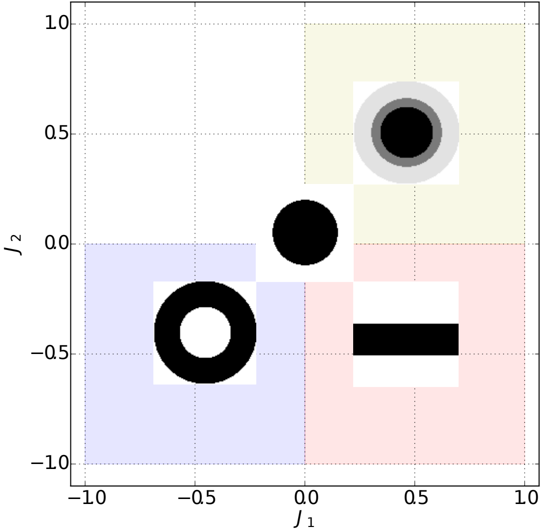
$$J_1 = \frac{Am - 4\pi I_1}{Am + 4\pi I_1}$$

$$J_2 = \frac{Am - 4\pi I_2}{Am + 4\pi I_2}$$



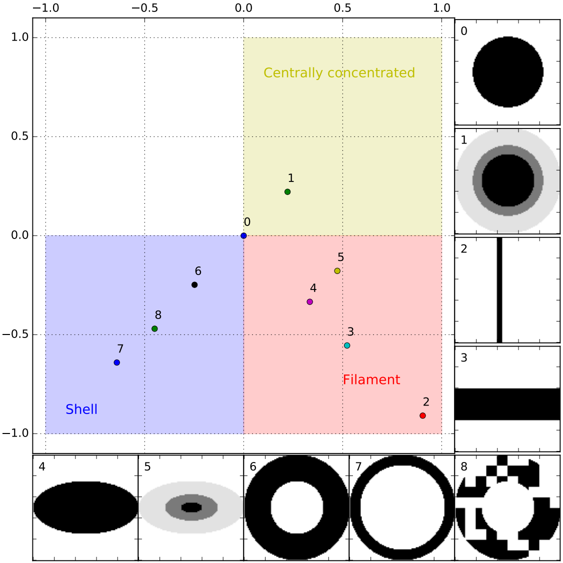
$$J_1 = \frac{Am - 4\pi I_1}{Am + 4\pi I_1}$$

$$J_2 = \frac{Am - 4\pi I_2}{Am + 4\pi I_2}$$

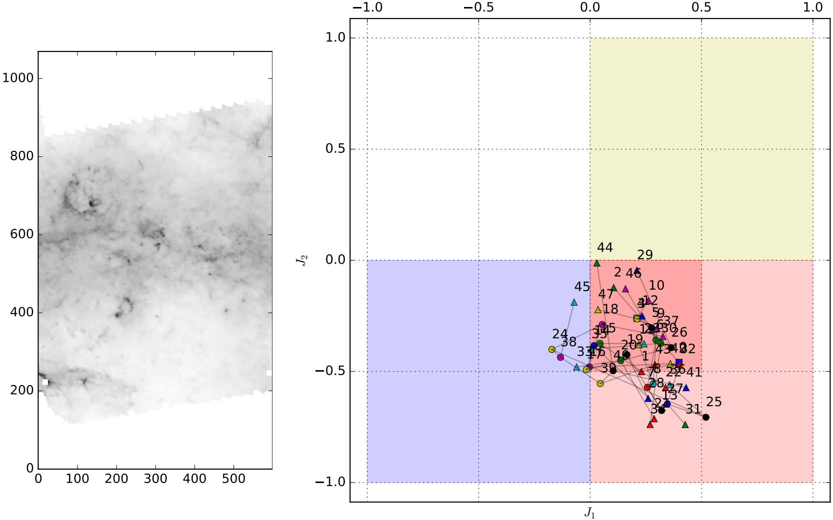


$$J_1 = \frac{Am - 4\pi I_1}{Am + 4\pi I_1}$$

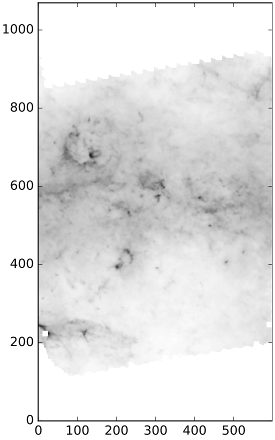
$$J_2 = \frac{Am - 4\pi I_2}{Am + 4\pi I_2}$$



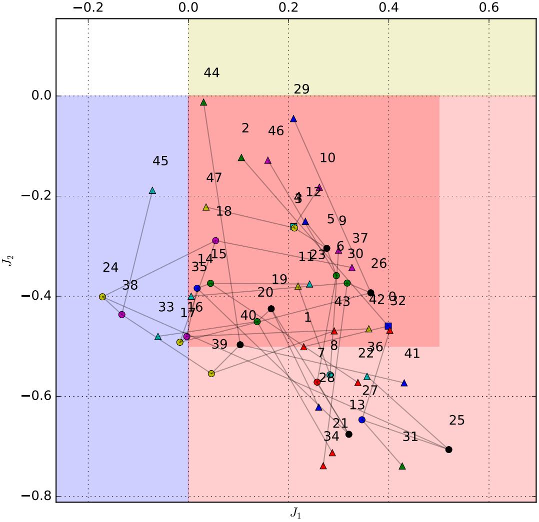
RCW 120



RCW 120

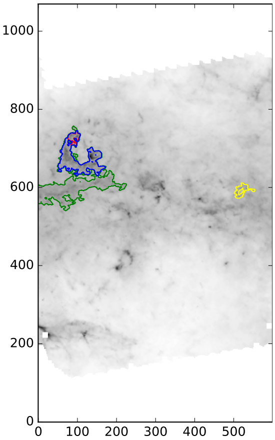


1000
800
600
400
200
0
0 100 200 300 400 500

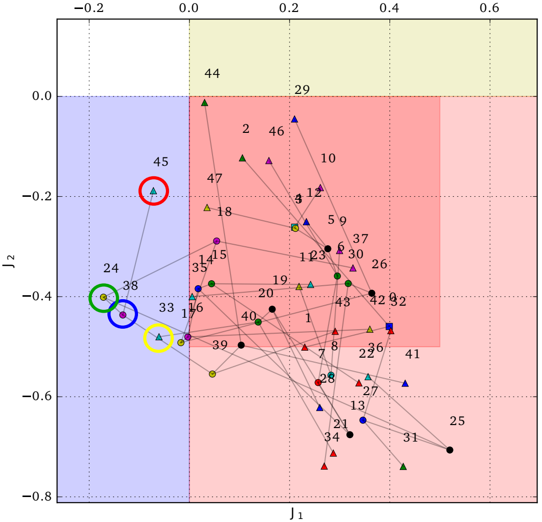


−0.2 0.0 0.2 0.4 0.6
0.0
−0.2
−0.4
−0.6
−0.8
J_2
J_1

Rings

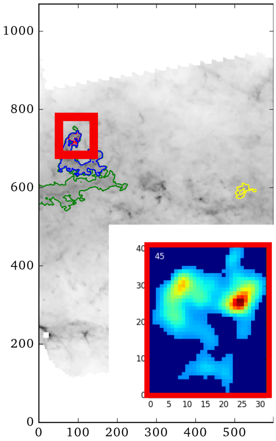


1000
800
600
400
200
0
0
100
200
300
400
500

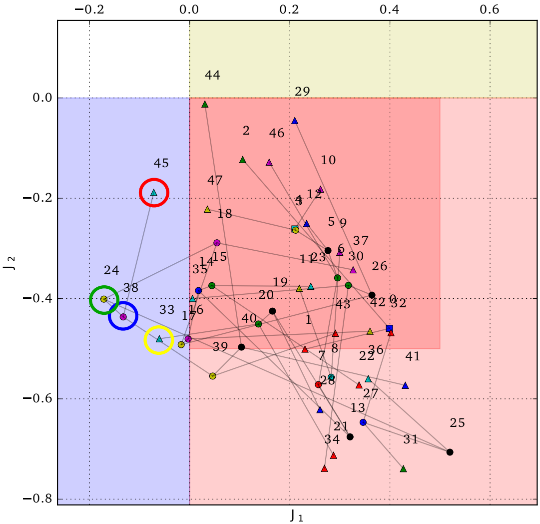


−0.2
0.0
0.2
0.4
0.6
0.0
−0.2
−0.4
−0.6
−0.8
J_1
J_2

Rings

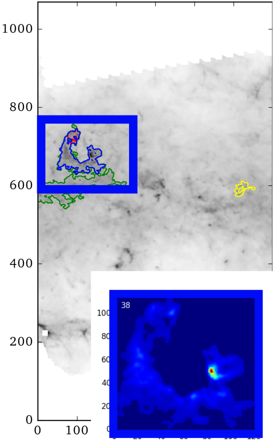


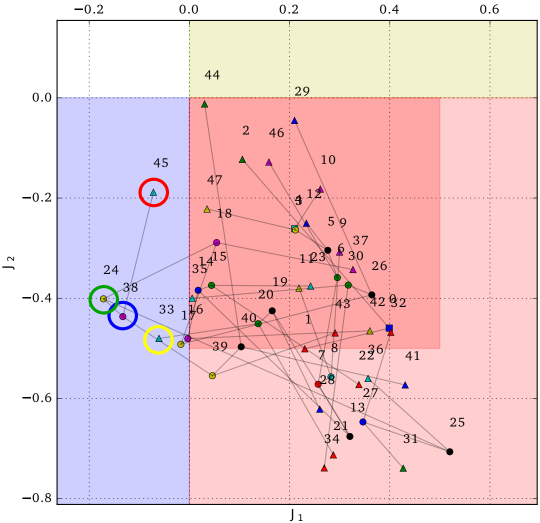
1000
800
600
400
200
0
0 100 200 300 400 500
45



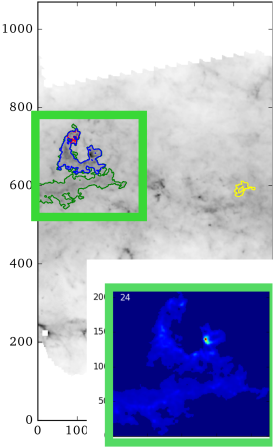
−0.2 0.0 0.2 0.4 0.6
0.0
−0.2
−0.4
−0.6
−0.8
J 2
J 1

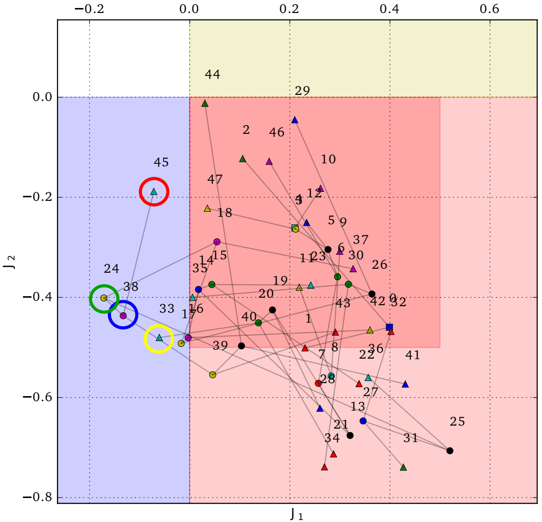
Rings



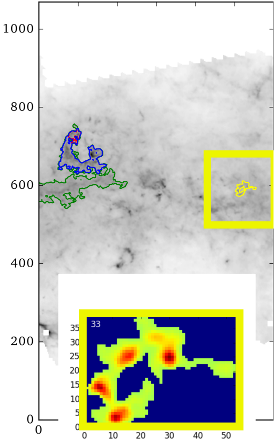

J 1
J 2
44
29
2
46
10
45
47
18
12
5
9
37
30
26
24
38
33
39
25
31
21
34
13
27
28
41
22
36

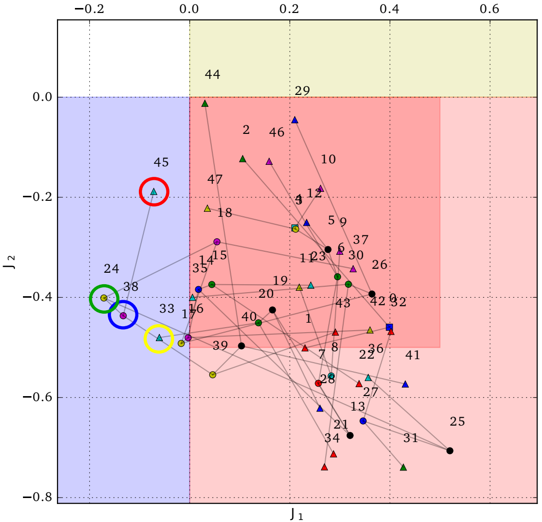
Rings


1000
800
600
400
200
0
0
100
24

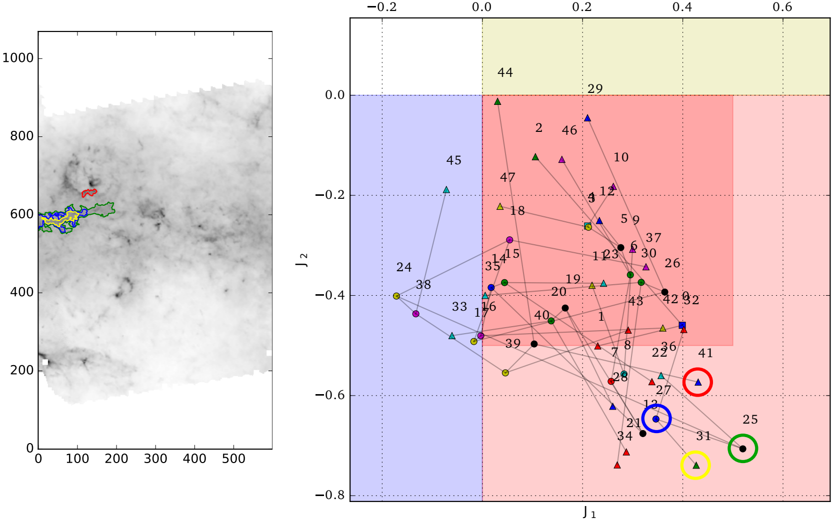

−0.2
0.0
0.2
0.4
0.6
0.0
−0.2
−0.4
−0.6
−0.8
J_1
J_2
44
29
2
46
10
45
47
12
18
5
9
37
30
26
24
38
15
19
20
33
16
17
40
1
43
42
32
39
7
8
22
36
41
28
27
13
21
34
31
25

Rings

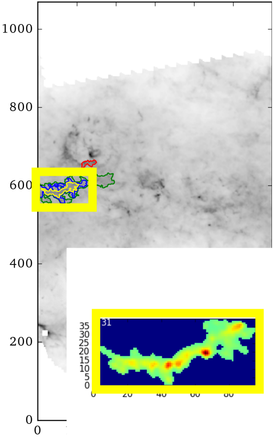


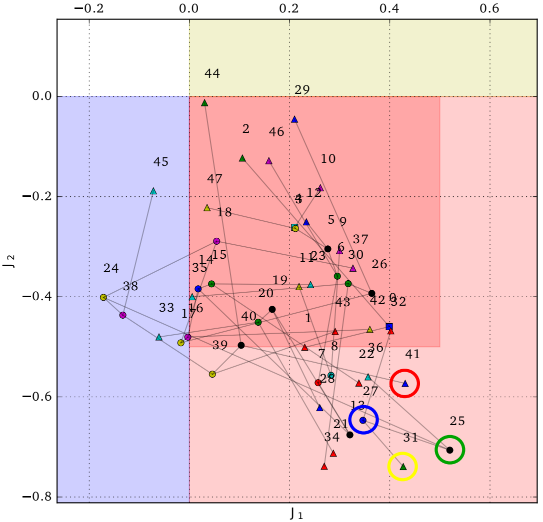


Filaments

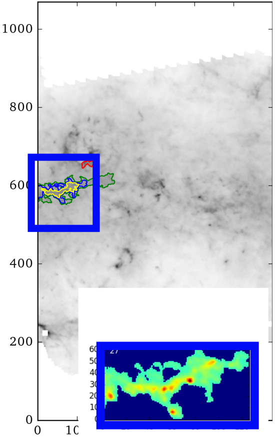


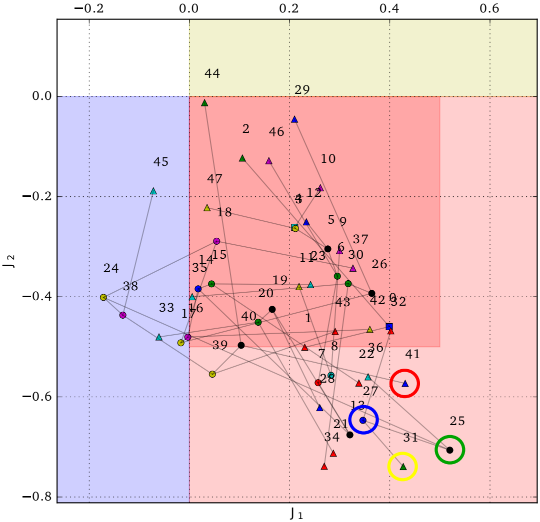
Filaments


1000
800
600
400
200
0
0
31
35
30
25
20
15
10
5
0
0
20
40
60
80

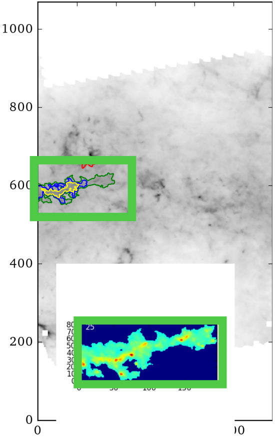

−0.2
0.0
0.2
0.4
0.6
0.0
−0.2
−0.4
−0.6
−0.8
J 2
J 1

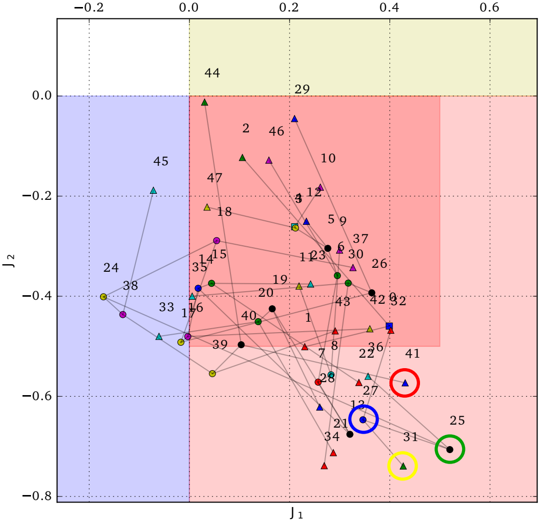
Filaments



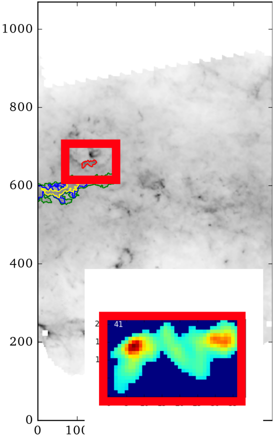


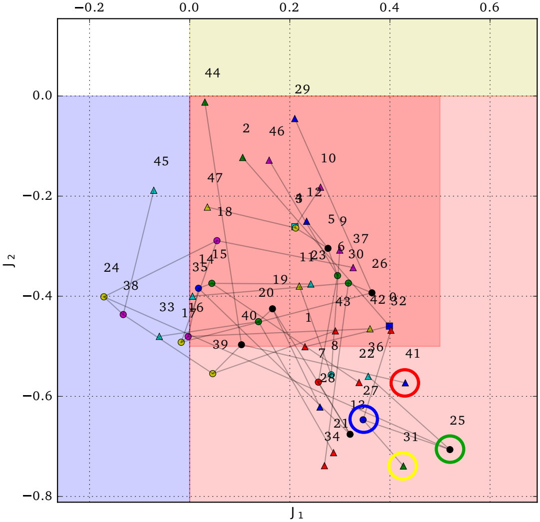
Filaments





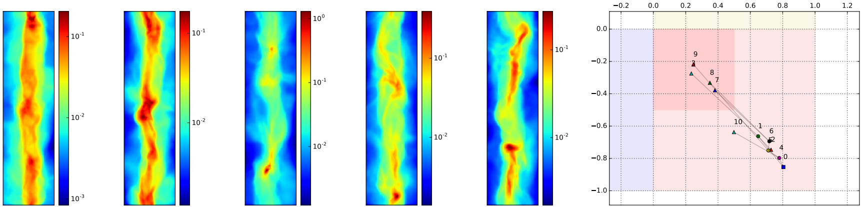
Filaments





Simulations (Clarke et al. 2017)

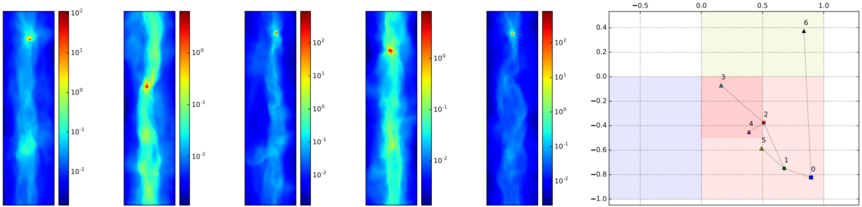
SPH simulations of fragmentation in accreting filaments in a turbulent medium, using either solely compressive turbulence or natural mix.



'increased turbulence causes elongated fibre-like structures to form within the main filament, which is reminiscent of the fray and fragment scenario of fibre production in situ proposed by Tafalla & Hacar (2015).'

Simulations (Clarke et al. 2017)

SPH simulations of fragmentation in accreting filaments in a turbulent medium, using either solely compressive turbulence or natural mix.



‘increased turbulence causes elongated fibre-like structures to form within the main filament, which is reminiscent of the fray and fragment scenario of fibre production in situ proposed by Tafalla & Hacar (2015).’

Future plans

- Where is the boundary between ‘elongated blob’ and ‘filament’?
- Compare to known catalogues of bubbles/filaments.
- Morphological evolution of fragments in simulations.
- 3D (PPP and PPV).

Summary

We can **separate structures in an image** using dendrograms and then use the principal moment of inertia of these structures to **classify their shapes**.

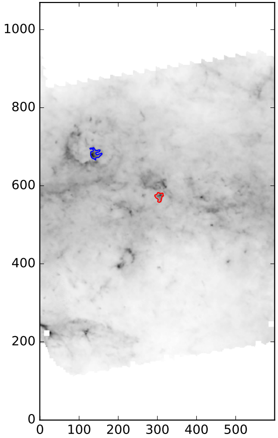
This code is able to separate centrally concentrated structures (**cores**), elongated structures (**filaments**) and hollow circular structures (**bubbles**) from the main population of ‘slightly irregular blobs’ that make up most astronomical images.

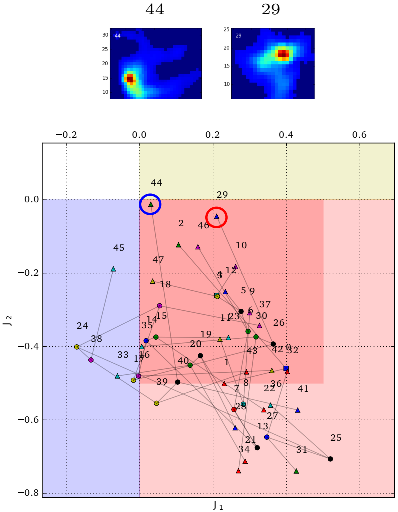
This can be applied to **any greyscale image** (single wavelength/tracer or column density) and could be **extended to 3D**.

Extra

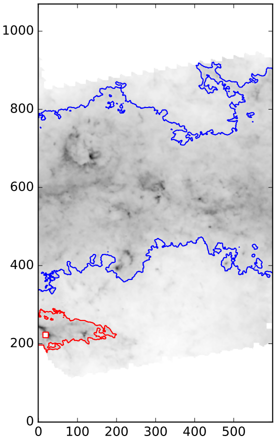
Extra Material

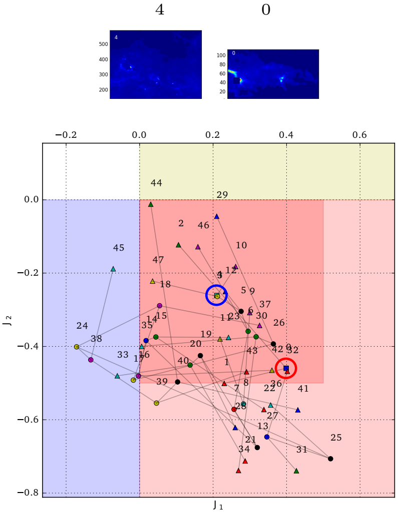
Other interesting points



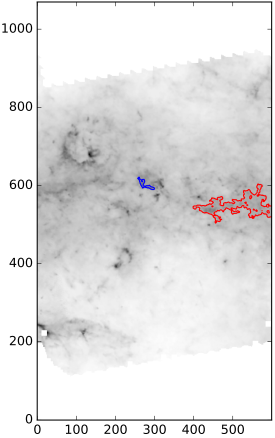


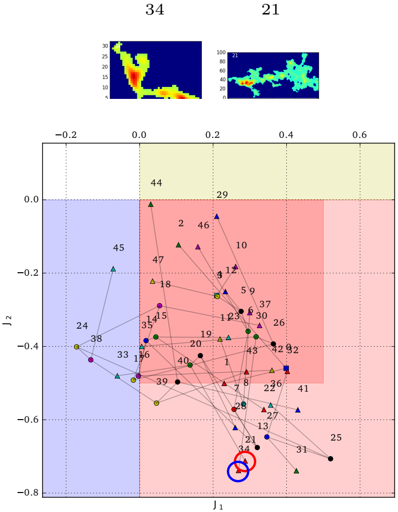
Other interesting points



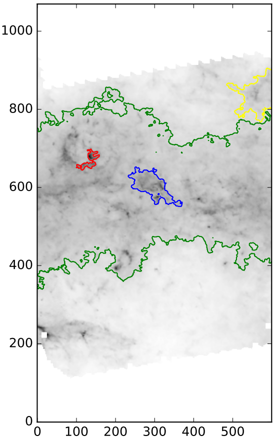


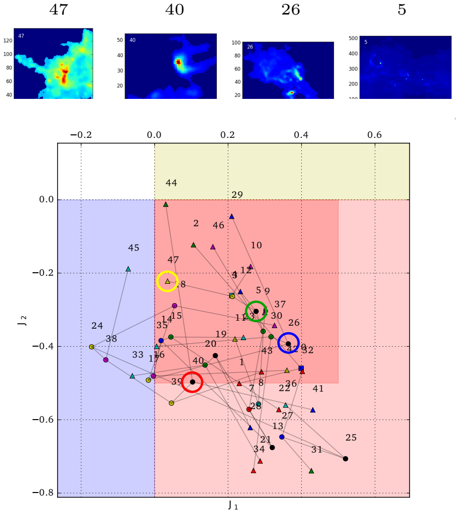
Other interesting points





Other interesting points





Summary

We can **separate structures in an image** using dendrograms and then use the principal moment of inertia of these structures to **classify their shapes**.

This code is able to separate centrally concentrated structures (**cores**), elongated structures (**filaments**) and hollow circular structures (**bubbles**) from the main population of 'slightly irregular blobs' that make up most astronomical images.

This can be applied to **any greyscale image** (single wavelength/tracer or column density) and could be **extended to 3D**.

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD