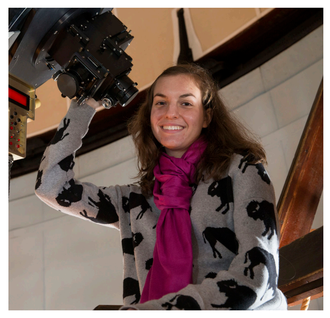
The Physical Properties of Large-Scale Galactic Filaments

Catherine Zucker, Alyssa Goodman, Cara Battersby

Harvard-Smithsonian Center for Astrophysics

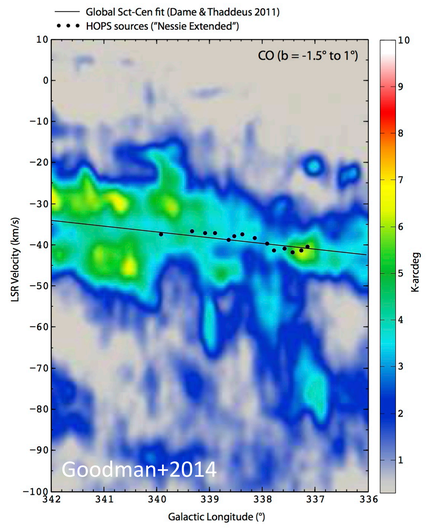


catherine.zucker@cfa.harvard.edu

Nessie is a "Bone" of the Milky Way

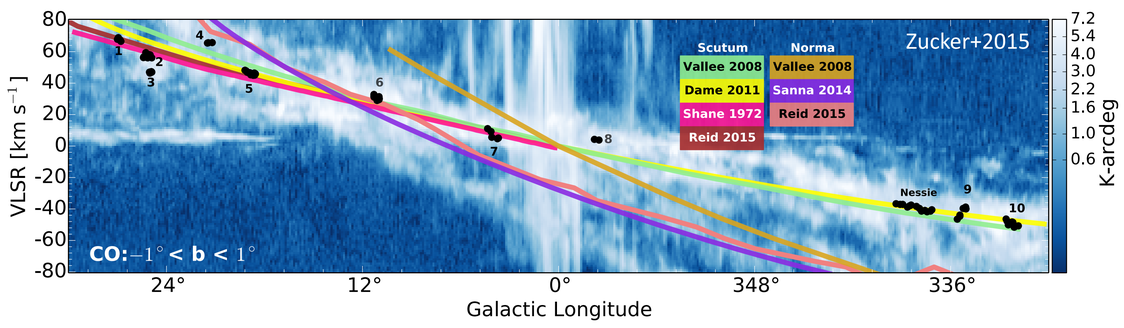
1 The infrared dark cloud "Nessie" seen in extinction. Its length (160+ pc) and aspect ratio (>300:1) suggests its formation is due to the global spiral potential of the Galaxy.

2 Nessie lies within 3 pc of the physical Galactic midplane (dashed colored line), at d=3.1 kpc

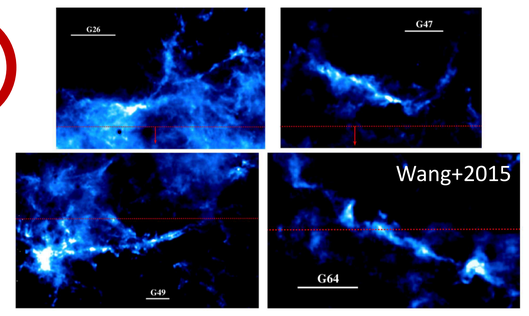


3 Nessie's velocity gradient *exactly* matches the global-log spiral fit to the Scutum Centaurus Arm in p-v space

And it may have friends!



6 **Large-Scale Herschel Filaments**: Dense, cold filaments (aspect ratios >>10) chosen through visual inspection of Hi-GAL images. Confirmed velocity contiguous through ^{13}CO GRS data (Wang+2015)



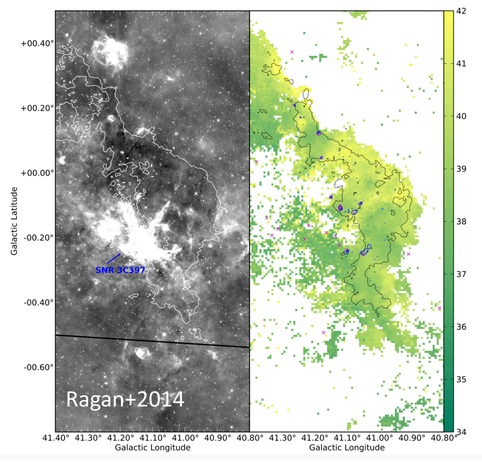
4 **Milky Way Bones**: Ultra-dense, high aspect ratio Nessie analogs that may form the "Skeleton" of the Milky Way. Analogs must satisfy quantitative Bone criteria (Zucker+2015)

Nessie Analog from Zucker+2015

2.3. Establishing "Bone" Criteria

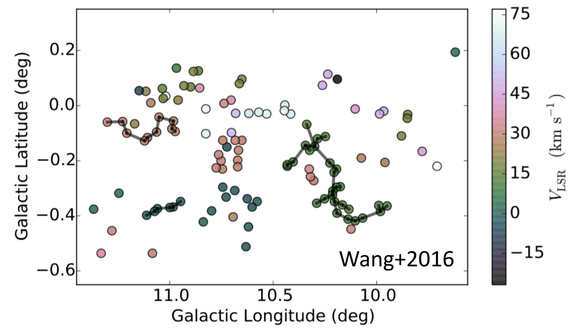
After narrowing down our list to 10 filaments with kinematic structure consistent with existing spiral arm models, we develop a set of criteria for an object to be called a "bone":

1. Largely continuous mid-infrared extinction feature
2. Parallel to the Galactic plane, to within 30°
3. Within 20 pc of the physical Galactic mid-plane, assuming a flat galaxy
4. Within 10 km s^{-1} of the global-log spiral fit to any Milky Way arm
5. No abrupt shifts in velocity (of more than 3 km s^{-1} per 10 pc) within extinction feature
6. Projected aspect ratio $\geqslant$50:1.



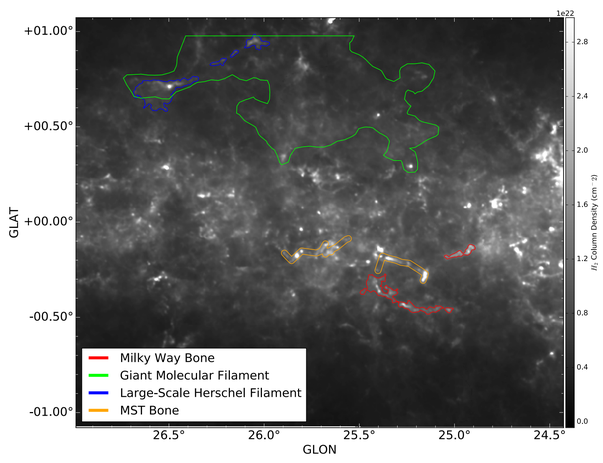
5 **Giant Molecular Filaments**: 70+ pc lower density filaments traced mainly by ^{13}CO, with typical aspect ratios between 5:1-10:1 (Ragan+2014, Abreu-Vicente+2016)

7 **MST Bones**: Filaments created by connecting dense BGPS N_2H+/HCO+ sources in p-p-v space using Minimum Spanning Tree algorithm. Must also satisfy additional Bone criteria based on Zucker+2015 criteria (Wang+2016)



But they have different properties and utility in tracing spiral structure

8 Size Scale Comparison of Large-Scale Filament Catalogs: Herschel column density map with filament outlines overlaid



10 Systematic offsets in column density (top left), temperature (top right), scale height (bottom left) and position angle (bottom right) among different classes

9 Filament Venn Diagram: Only 18% of large-scale filaments share any overlap with other large-scale filament catalogs