Discovery of a Thin Circular Thirty-Degree-Long Ultraviolet Arc Around the Big Dipper

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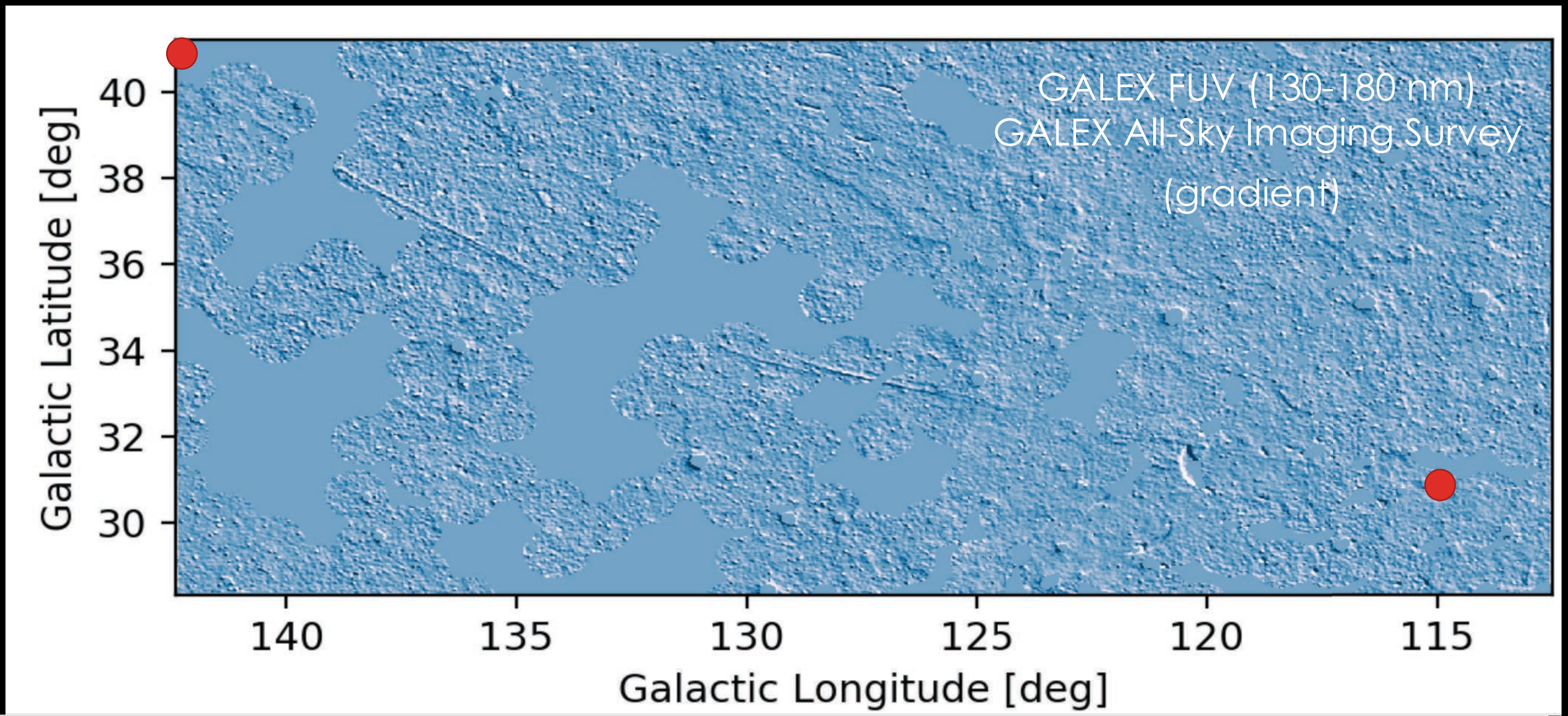
Stellarium view from Chicago @2:20am on Jun 4

The Ursa Major Arc

NASA's GALEX (Galaxy Evolution Explorer)
All-Sky Imaging Survey
Far Ultraviolet (130-180 nm) *and* Near Ultraviolet (170-280 nm)

and

Hα (656 nm) emission: MDW (Mittelman-di Cicco-Walker) survey



DISCOVERY

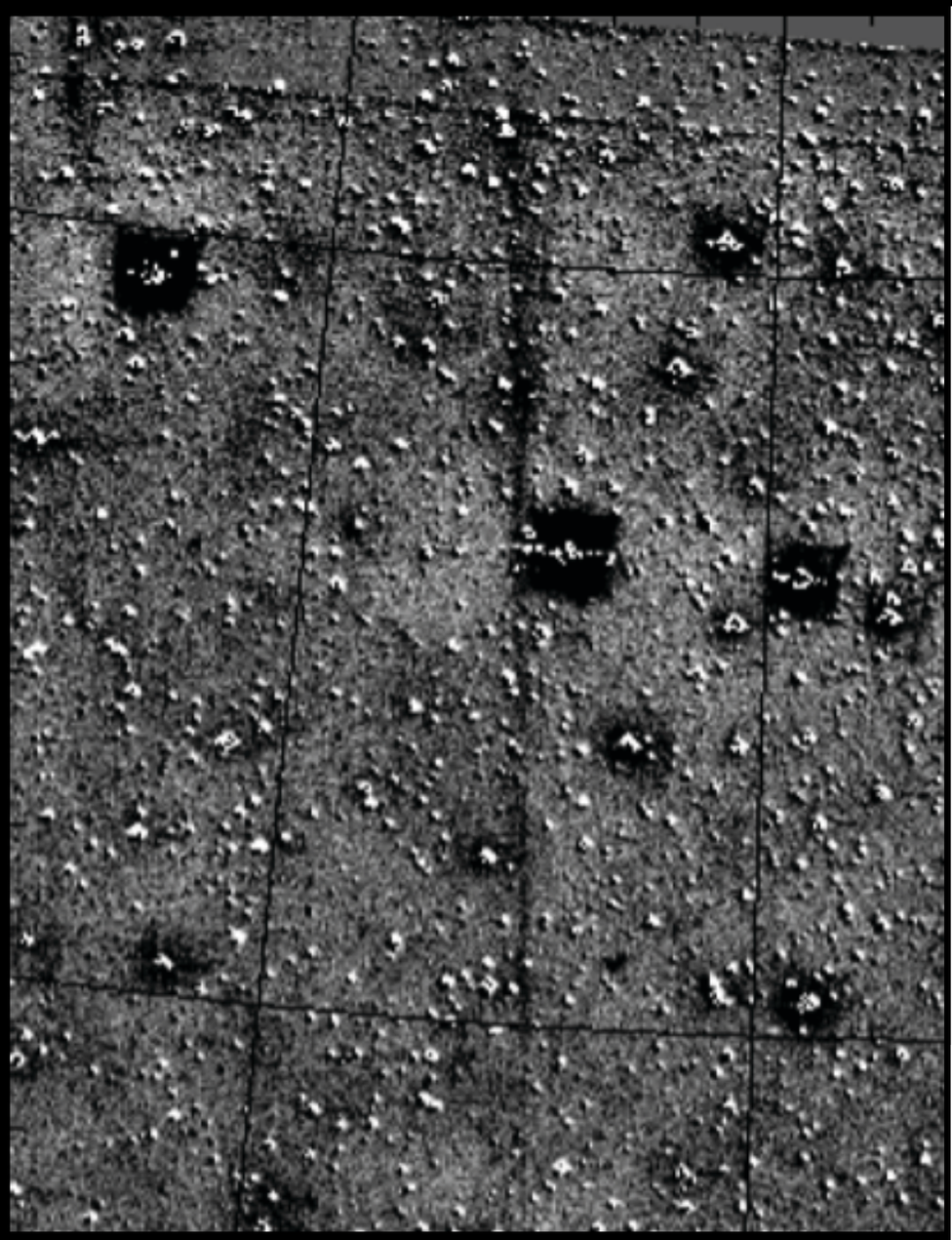


Figure 1 —McCullough & Benjamin (2001)

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A STRAIGHT AND NARROW IONIZED FILAMENT

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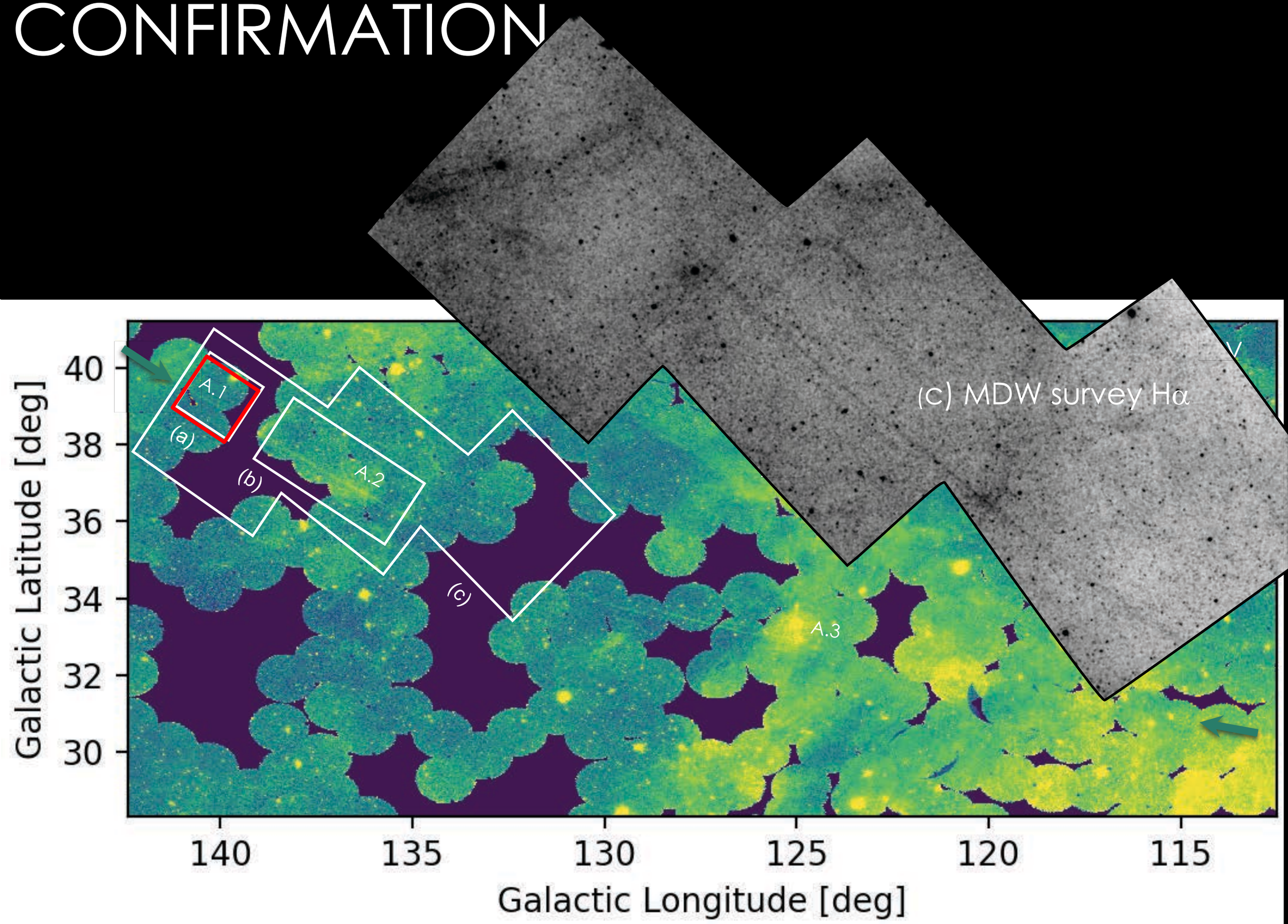
ABSTRACT

We report the discovery of an extremely narrow, extremely linear, ionized filament. The filament is $\sim 2\overset{\circ}{.}5$ long and has an Hα surface brightness of ~ 0.5 R. It is at high galactic latitude, stretching from $(l, b) = (140\overset{\circ}{.}8°, 39\overset{\circ}{.}0)$ to $(138\overset{\circ}{.}0, 37\overset{\circ}{.}7)$. The filament is approximately Y-shaped. The vertical segment of the Y is $\sim 1\overset{\circ}{.}2$ long and $\sim 20''$ wide, and the widest separation of the two diagonal segments is $\sim 5'$. We discuss four possible origins for this feature: (1) an extremely low density, nearby jet; (2) an unusually linear filament associated with some large-scale nearby nebula, perhaps even the Local Bubble; (3) an ionized trail left by mechanical input from a star or compact object moving through the interstellar medium (ISM); or (4) an ionized trail left by photoionization ("Fossil Strömgren Trail") from a star or compact object. We favor this last hypothesis, and derive some of the basic properties for an ionized trail. Regardless of whether this latter hypothesis applies to this specific filament, the basic properties of such a trail, its length, width, and brightness, are interesting, predictable, and should be observable behind some white dwarfs. If the filament is a photoionized trail, then the source should be closer than a few hundred parsecs, with a measurable proper motion and a luminosity of hydrogen ionizing photons of $\lesssim 10^{44}$ ergs s^{-1}. We have searched for such sources in line with the filament and find one candidate, the X-ray source RX J094247.2+700238. If the M dwarf binary star Gl 360 is the optical counterpart of the X-ray source, as has been thought, then its proper motion eliminates it as a candidate, and we have no other potential candidate to leave a trail. We note the similarity of this structure to long, narrow features ("canals") observed as depolarizing regions against the Galactic synchrotron background and find that this emission filament may also be detectable as a region of Faraday depolarization. We suggest future tests for ascertaining the origin of this filament and discuss how this structure might be useful to constrain the thermal and velocity structure of the nearby ISM.

Key words: ISM: general

"For reasonable interstellar parameters, the filament described in this paper could produce a Faraday depolarization."

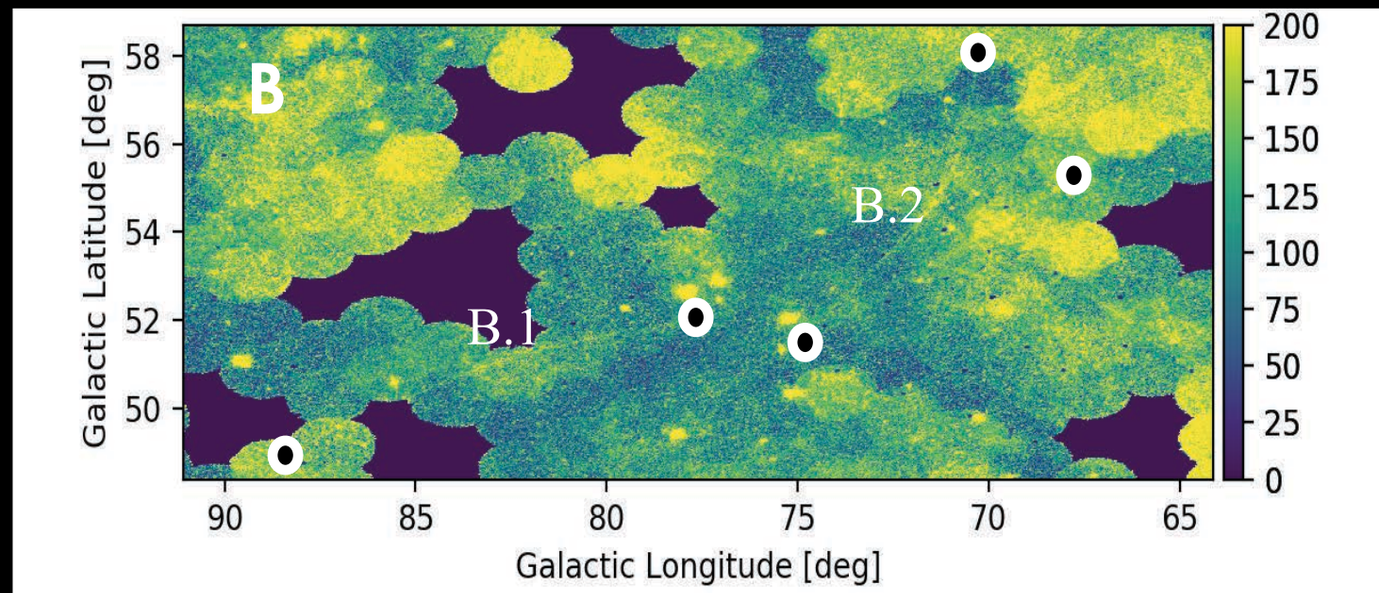
CONFIRMATION

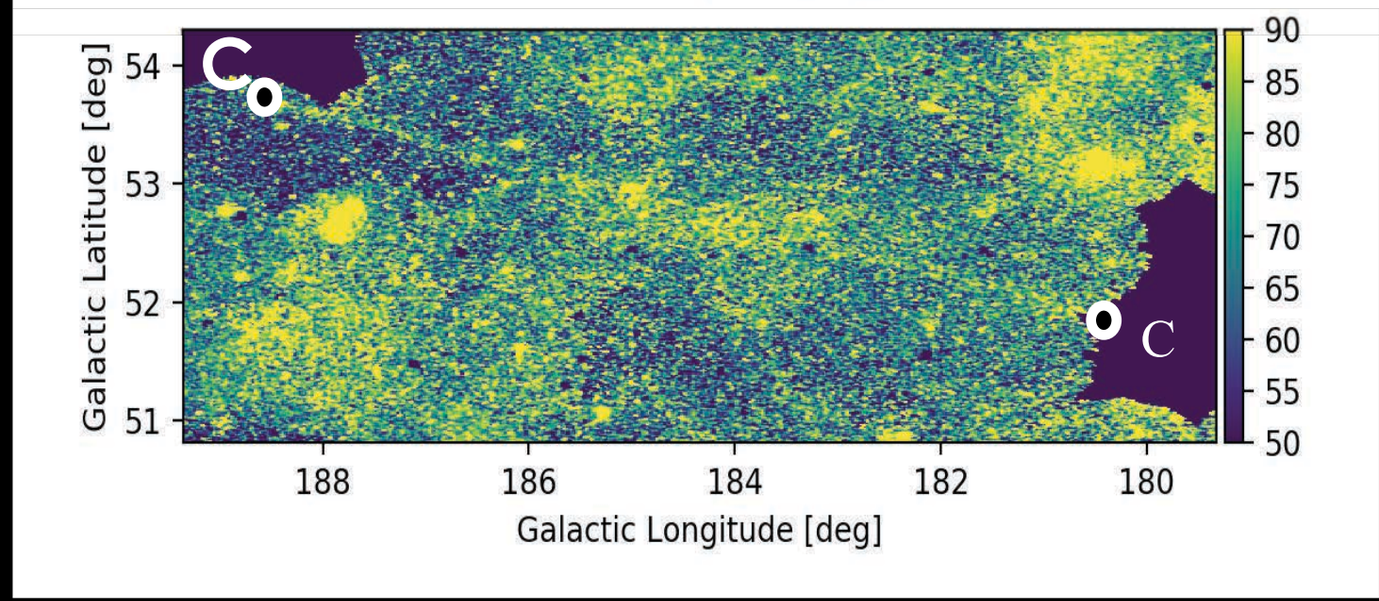


BASIC CHARACTERISTICS

- Arc Length: 30 degrees
- Direction: (l,b)=(115°.4, 30°.7) to (147°.7,43°.5)
- Multiple arclets
- Arc Center: (l,b)=(107°.7, 60°.0)
- Arc Radius: 29°.28±0°.23 (0.8%) ±0°.16 (0.6%)
- Thickness: 0.3 to ~1 arcminute

Other large arcs found in GALEX AIS (B,C), but not common.

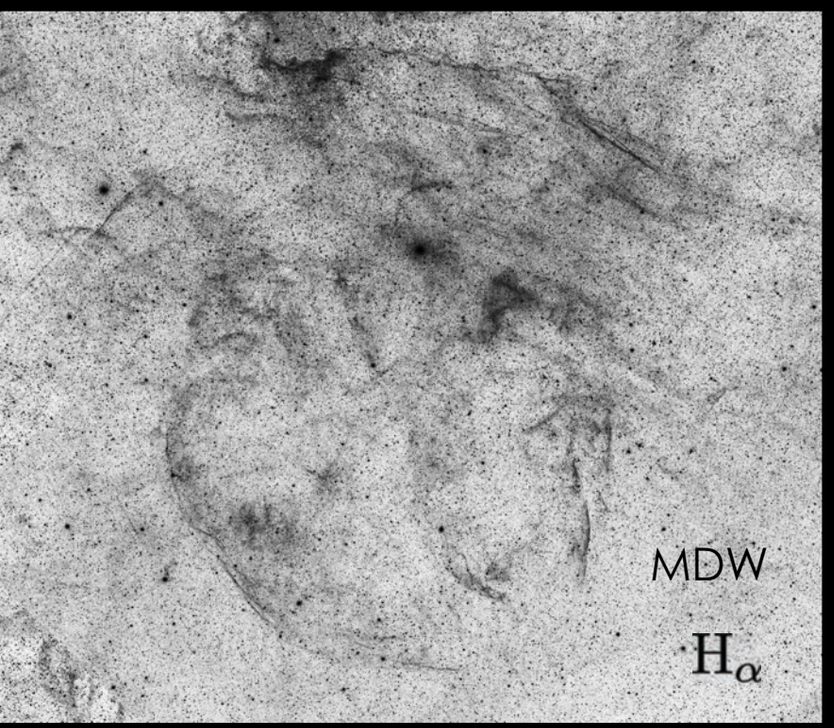


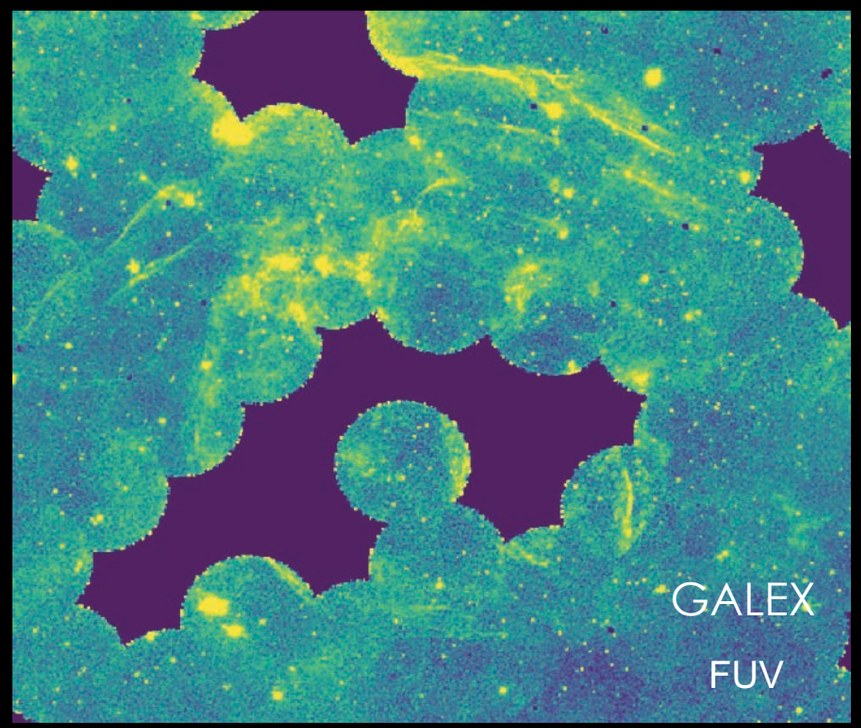


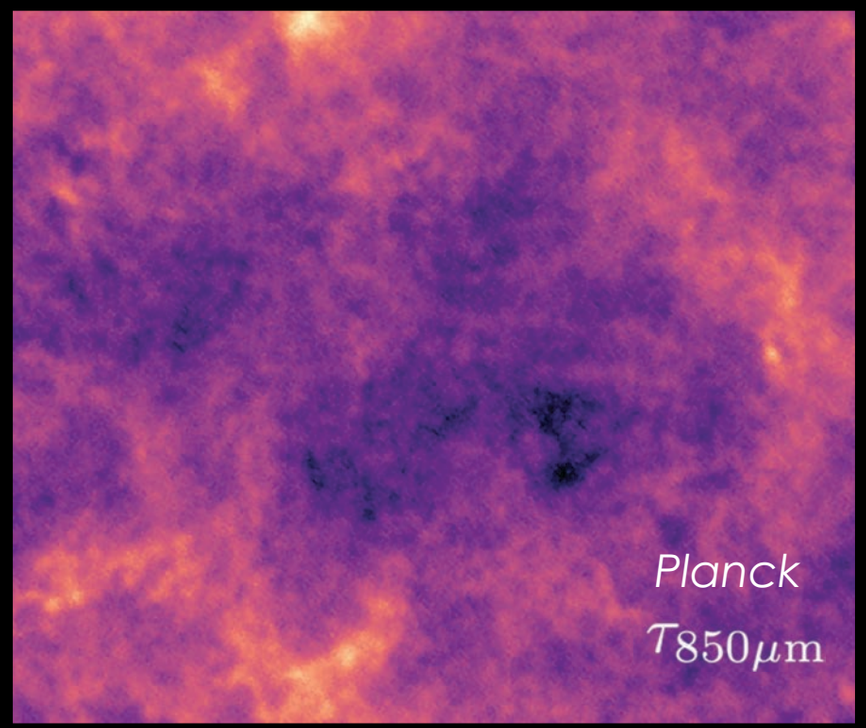
Source of ultraviolet emission: "Two-photon emission" from hydrogen gas

What is it? A old, very nearby supernova remant

8 degrees







Supernova remnant (SNR) G070.0-21.5

Comparable large angular-scale old supernova remnants

SNR	Ref	L	B	D	X-rays	Notes
Antlia	McCullough et al 2002	276.5	+19.0	24°	Yes	Discovered in Hα
G70.0-21.5	Fesen et al 2015 Raymond et al 2020	70.0	–21.5	8°	Yes	Discovered in Hα v_{shock}~100 km/s?
G353-34	Testori et al 2008	353.0	–34.0	10°	No	Discovered in radio synchrotron

Origin & Implications

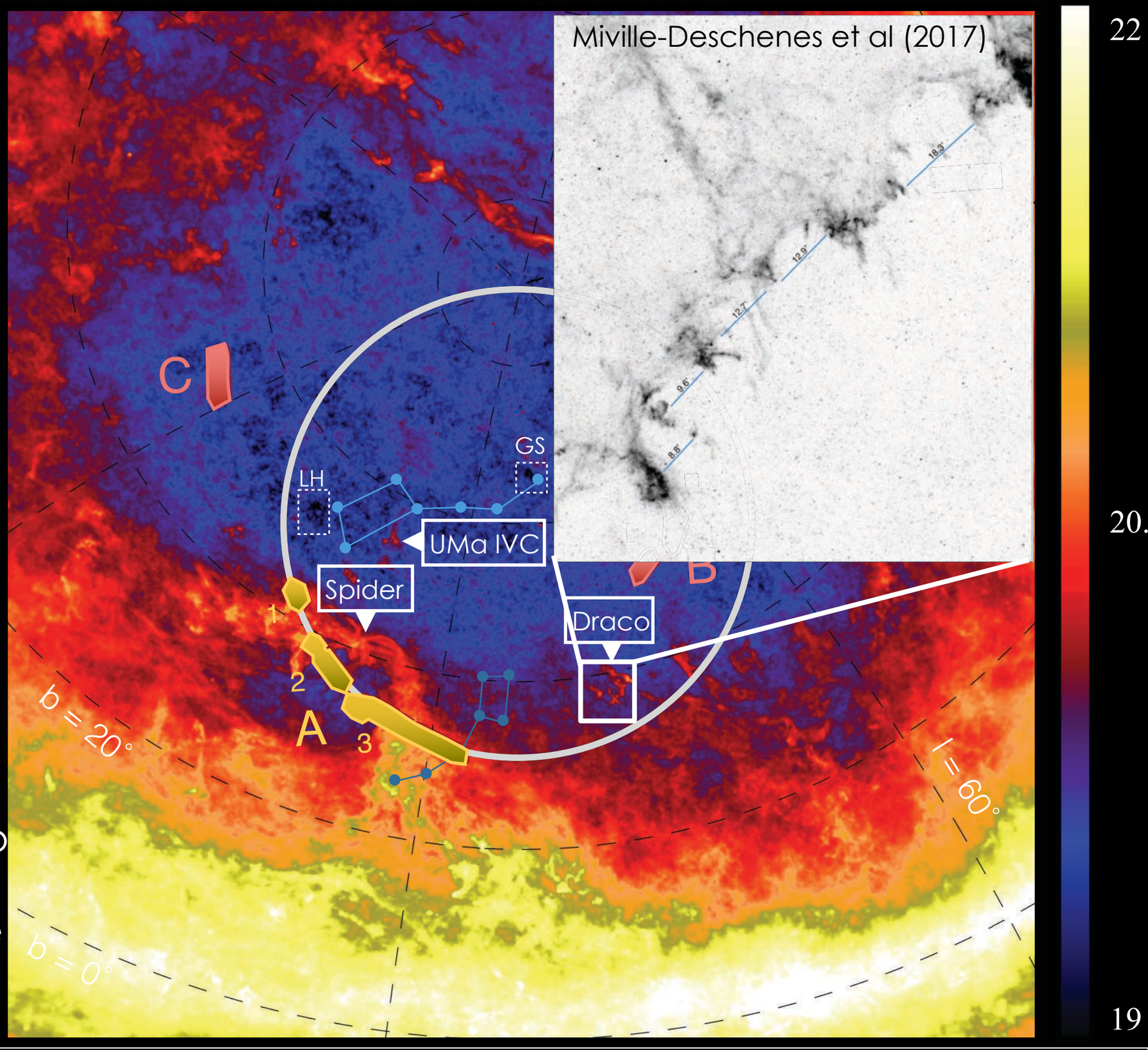
Ursa Major "Circle"

- 2681 square degrees; Nearly a third of sky above b=30°

- Explosion may have contributed to "Local Chimney" (Welsh et al 1999)

- May have created low density windows to look out of our Galaxy
  LH=Lockman Hole
  GS=Groth Strip

- Draco cloud (d=481±50 pc) interior to bubble? If so, R_{UMa}>300 light years and distance to center > 600 light years.



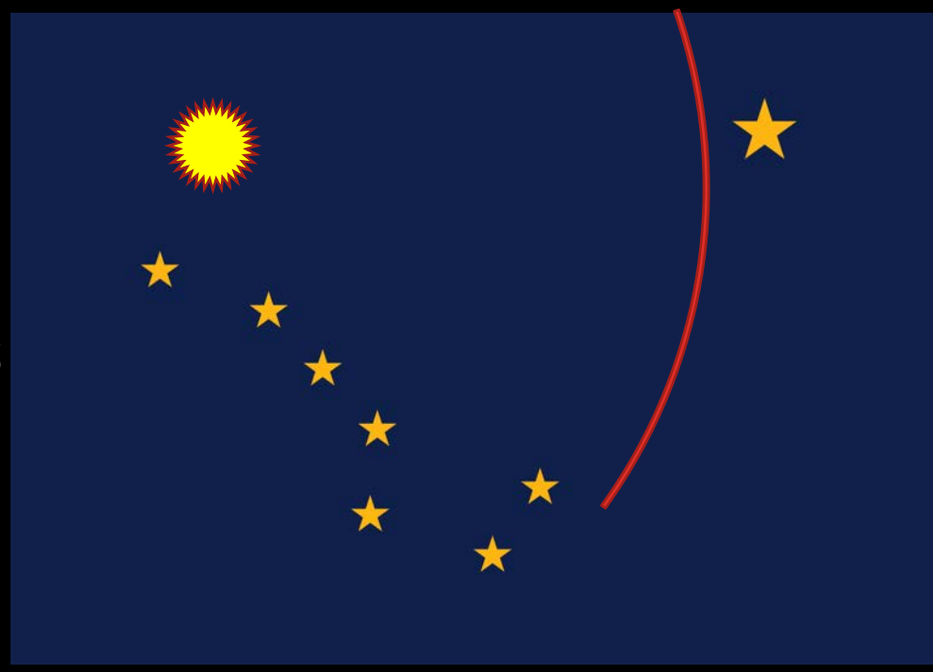
CONCLUSIONS

- The 2.5 degree "straight and narrow filament" of 2001 was less straight than we thought! It's a 30° long curved shock front.

- Evidence for 60° diameter, old supernova remnant covering nearly one third of the northern sky above b=30°. This is larger (in angle) than the previous record holder (Antlia SNR) by a factor of three, and four times larger than Cygnus Loop, Vela SNR,

- Age/distance of explosion uncertain, but current estimate is ~100,000 yr and 600 light-years away.

- Probably related to interstellar windows in this direction. It may help us understand the structure of the interstellar medium above the Sun (over a significant fraction of the sky).



Modified version of Alaska state flag (Position of arc is an approximation)

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Press statement: https://www.uww.edu/news/archive/2020-06-ultraviolet-emission

Origin and Implications