# Decaying axion DM

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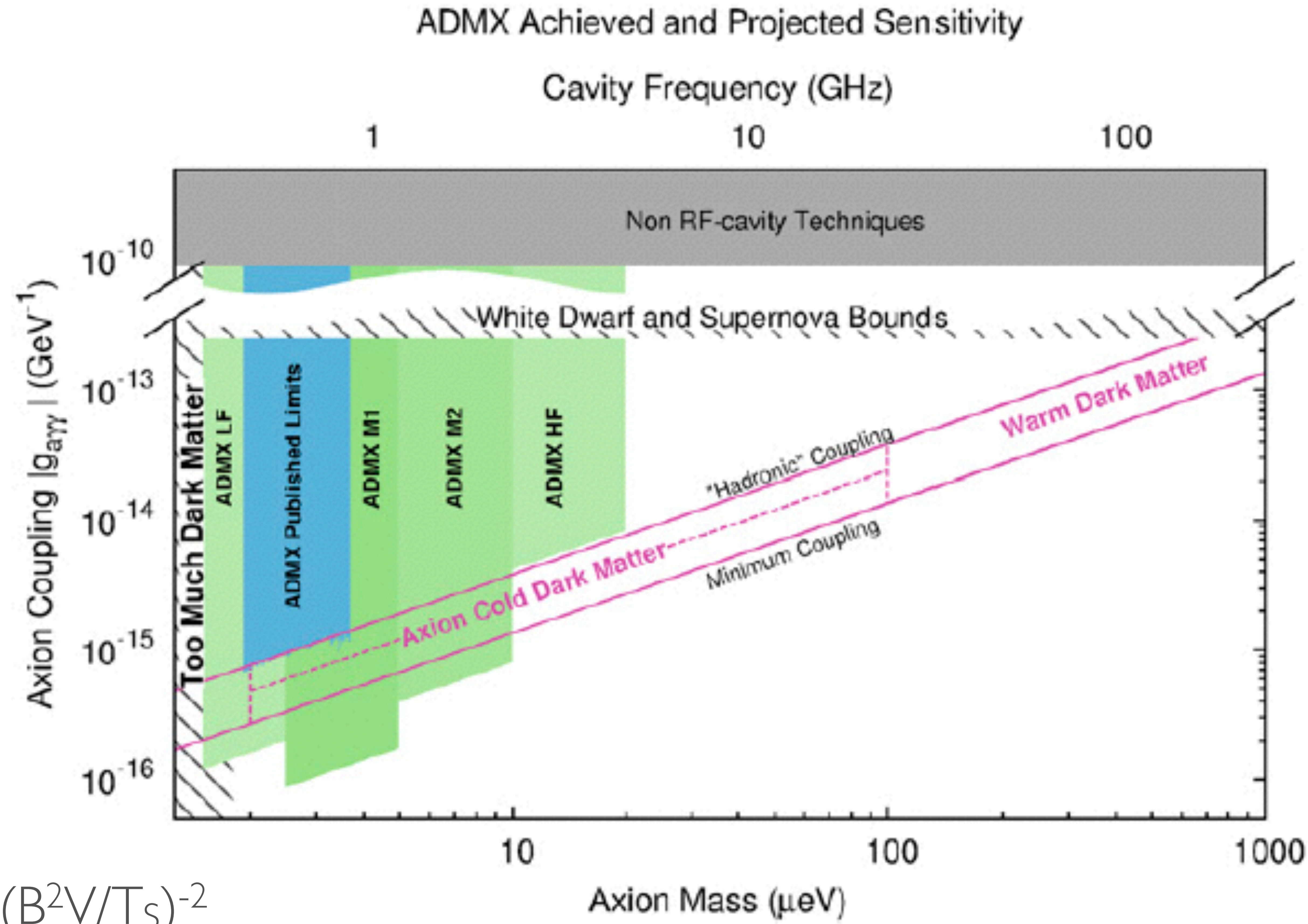
Axions in Spain, Zaragoza


ADMX Achieved and Projected Sensitivity
Cavity Frequency (GHz)
1
10
100
Non RF-cavity Techniques
White Dwarf and Supernova Bounds
Too Much Dark Matter
ADMX LF
ADMX Published Limits
ADMX M1
ADMX M2
ADMX HF
Warm Dark Matter
"Hadronic" Coupling
Axion Cold Dark Matter
Minimum Coupling
Axion Coupling |g_aγγ| (GeV^-1)
10^-10
10^-13
10^-14
10^-15
10^-16
10
100
1000
Axion Mass (μeV)

$(B^2V/T_S)^{-2}$

Assume we find a signal in the micro-to-milli eV region with couplings that some the strong CP problem.

How do we check the signal unequivocally corresponds to cold dark matter solving the QCD problem?

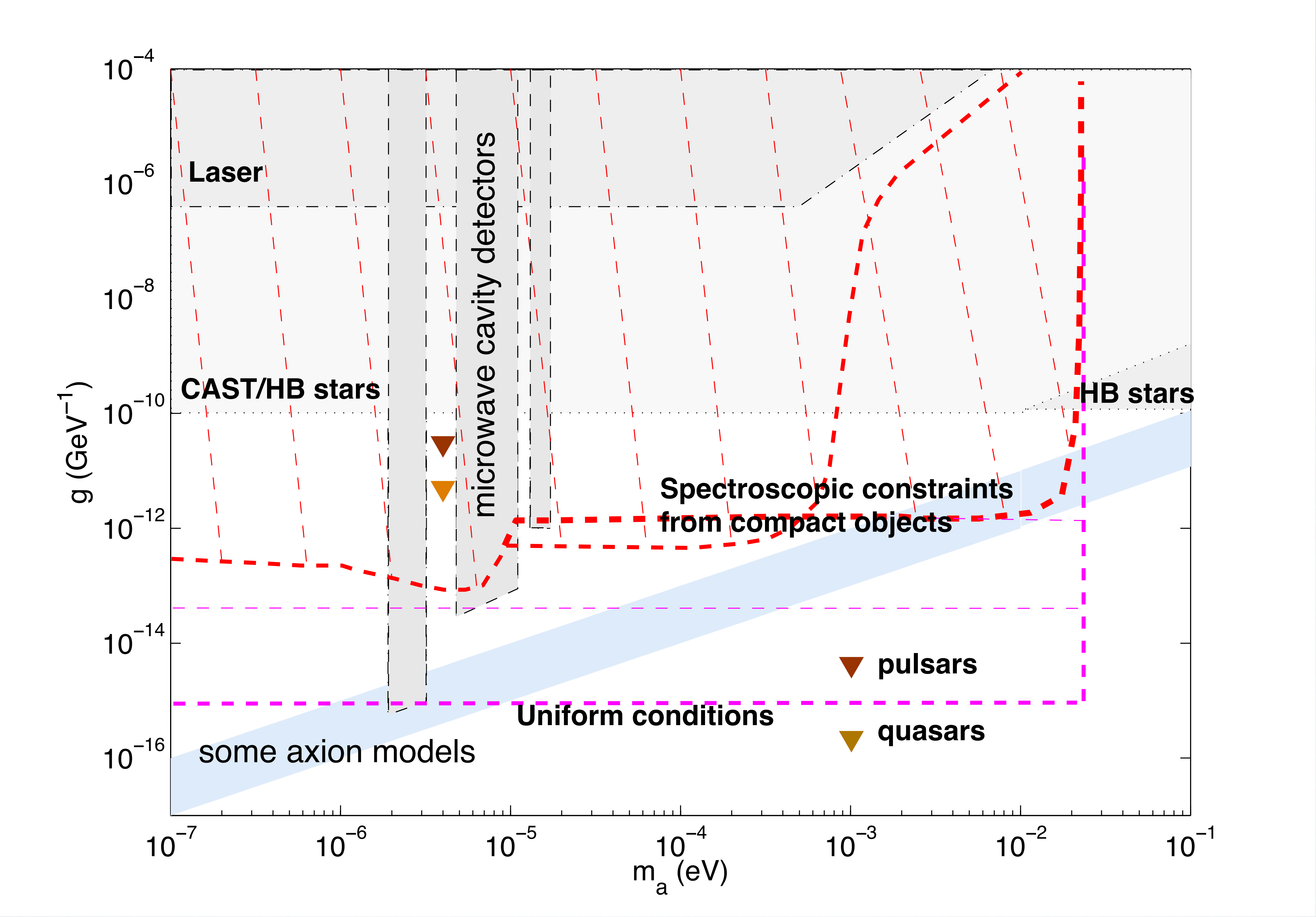
Among others:

a) play with resonant cavity parameters to verify

b) try other lab experiments to verify and further explore

c) find a dark matter source to confirm

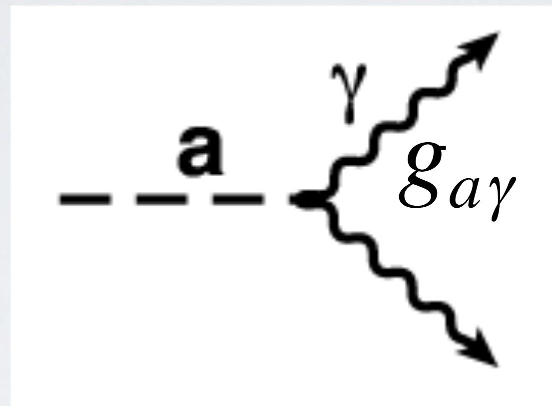
# Spectral shape & variability of highly magnetized plasmas




Conclusion: Learn about compact objects

**Chelouche et al, 2008**

Instead of searching for stimulated emission in a magnetic field, looking for spontaneous emission. Firstly proposed by Turner with eV axions

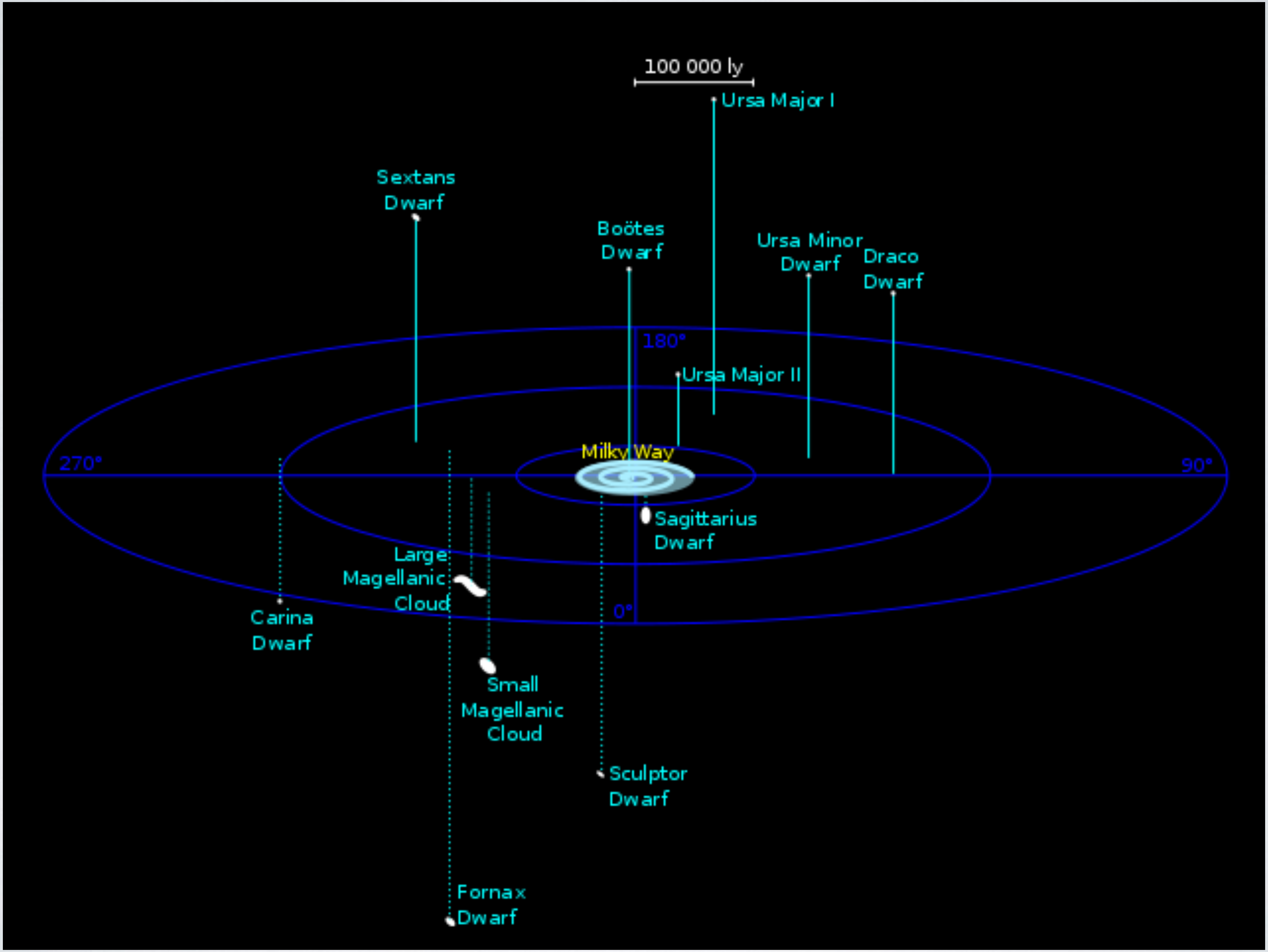



$$1/\Gamma_a = \frac{64\pi}{m_a^3 g_{a\gamma\gamma}^2}$$

$$g_{a\gamma\gamma} = \frac{\alpha}{2\pi}\left(\frac{E}{N} - \frac{2}{3}\frac{4+z}{1+z}\right)\frac{1+z}{z^{1/2}}\frac{m_a}{m_\pi f_\pi}$$

Flux from an axion dark matter halo:

$$\frac{\mathrm{d}\Phi}{\mathrm{d}\Omega} = \frac{2}{4\pi}\int_{l.o.s.} \frac{\rho(\ell)}{m_a \tau_a}\mathrm{d}\ell$$


100 000 ly
Ursa Major I
Sextans
Dwarf
Boötes
Dwarf
Ursa Minor
Dwarf
Draco
Dwarf
180°
Ursa Major II
Milky Way
270°
90°
Sagittarius
Dwarf
Large
Magellanic
Cloud
0°
Carina
Dwarf
Small
Magellanic
Cloud
Sculptor
Dwarf
Fornax
Dwarf

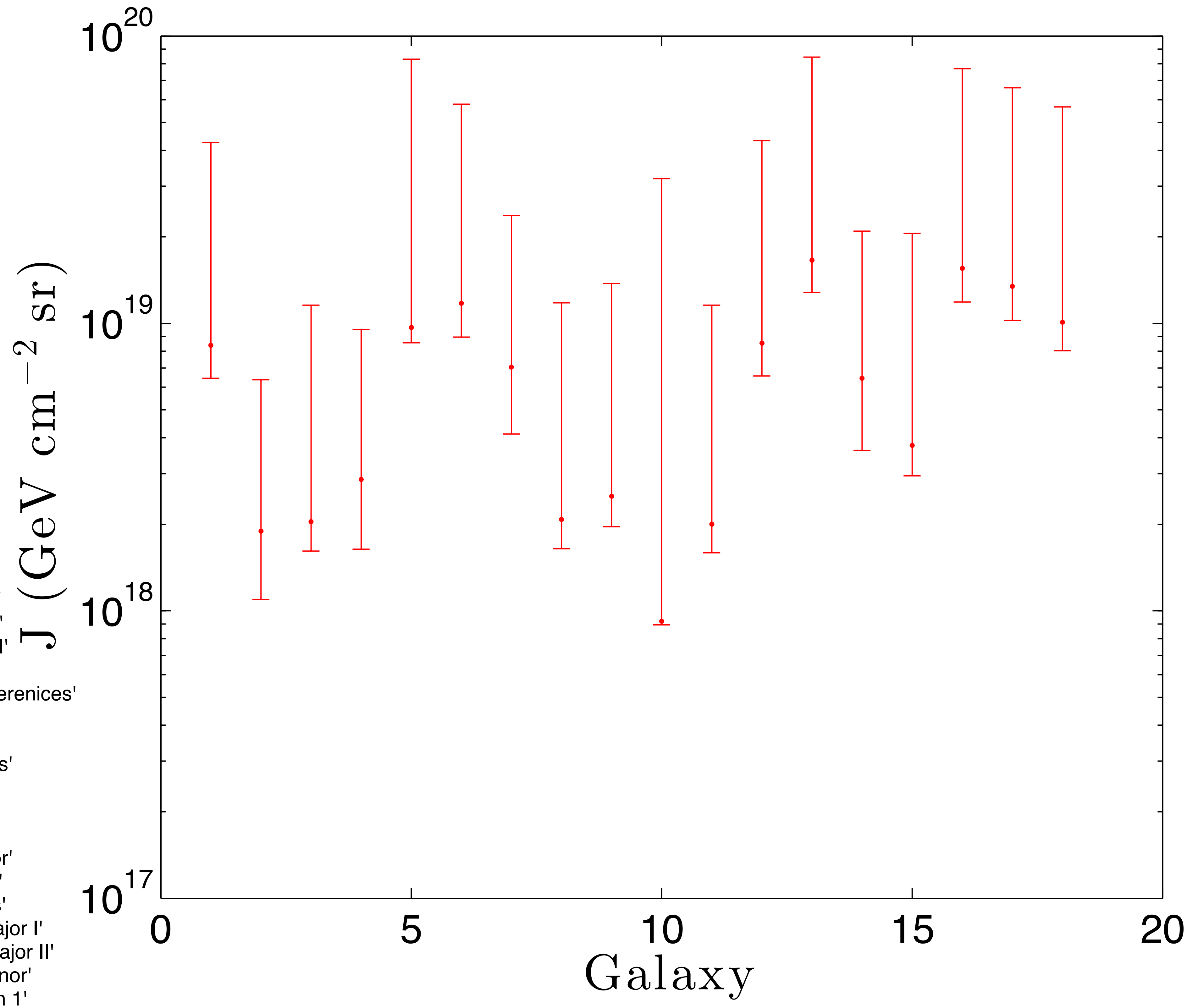
Size
Distance
(kpc)

| | | | | | |
|---|---|---|---|---|---|
| Canis Major Dwarf | 1.5 | 8 | | Irr | 2003 |
| Sagittarius Dwarf | 2.6 | 20 | | E | 1994 |
| Large Magellanic Cloud | 4 | 48.5 | | SBm | prehistori |
| Small Magellanic Cloud | 2 | 61 | | Irr | prehistori |
| Ursa Major II Dwarf | 0.2 | 30 | | dG D | 2006 |
| Ursa Minor Dwarf | 0.4 | 60 | | dE4 | 1954 |
| Draco Dwarf | 0.7 | 80 | | dE0 | 1954 |
| Sculptor Dwarf | 0.8 | 90 | | dE3 | 1937 |
| Sextans Dwarf Spheroidal | 0.5 | 90 | | dE3 | 1990 |
| Carina Dwarf Spheroidal | 0.5 | 100 | | dE3 | 1977 |
| Ursa Major I Dwarf | - | 100 | | dG D | 2005 |
| Fornax Dwarf | 0.6 | 140 | | dE2 | 1938 |
| Leo II | 0.7 | 210 | | dE0 | 1950 |
| Leo I | 0.5 | 250 | | dE3 | 1950 |
| Leo IV | 0.3 | 160 | | dSph | 2006 |
| Leo V | 0.08 | 180 | | dSph | 2007 |
| Leo T | 0.34 | 420 | | dSph/dIrr | 2006 |
| Boötes I | 0.3 | 60 | | dSph | 2006 |
| Boötes II | 0.1 | 42 | | dSph | 2007 |
| Boötes III | 1 | 46 | | dSph? | 2009 |
| Coma Berenices | 0.14 | 42 | | dSph | 2006 |
| Segue 1 | 0.06 | 23 | -3.0 | dSph | 2007 |
| Segue 2 | 0.07 | 35 | | dSph | 2007 |
| Canes Venatici I | 2 | 220 | | dSph | 2006 |
| Canes Venatici II | 0.3 | 155 | | dSph | 2006 |
| Hercules | 0.7 | 135 | | dSph | 2006 |
| Pisces I | | 80 | | dSph? | 2009 |
| Pisces II | 0.12 | 180 | | dSph | 2010 |

Size
Distance
(kpc)

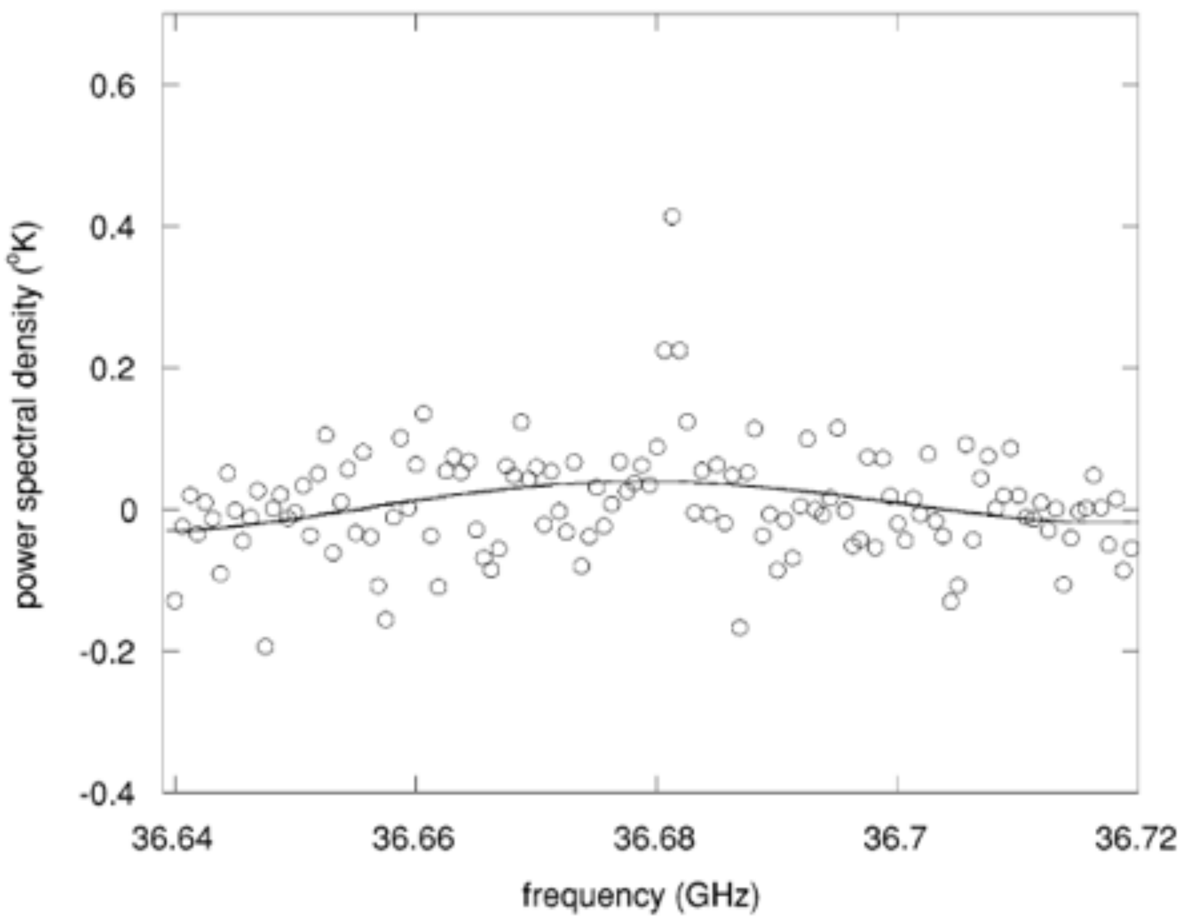
| | | | | | |
|---|---|---|---|---|---|
| Crater/Laevens I | 0.06 | 145 | | GC[7] | 2014 [8][9] |
| Reticulum II | - | 30 | | dSph | 2015 [10][11] |
| Eridanus II [12] | 0.55 | 366 | -7.1 | dSph | 2015 [10][11] |
| Horologium I | - | 100 | | dSph? | 2015 [10][11] [a] |
| Pictoris | - | 115 | | dSph? | 2015 [10][11] [a] |
| Phoenix II | - | 100 | | dSph? | 2015 [10][11] [a] |
| Kim 2/Indus I | - | 100 | | GC | 2015 [10][11] |
| Grus I | - | 120 | | dSph | 2015 [10] |
| Eridanus III | - | 90 | | dSph? | 2015 [10][11] [a] |
| Tucana II | - | 70 | | dSph | 2015 [10][11] |
| Triangulum II | 0.07 | 30 | -1.8 | dSph | 2015 |
| Hydra II | 0.14 | 128 | | dSph | 2015 [13] |
| Pegasus III | 0.11 | 215 | -3.4 | dSph | 2015 [14][15] |
| Grus II | 0.19 | 53 | | dSph | 2015 [16] |
| Tucana III | 0.09 | 25 | | dSph | 2015 [16] |
| Columba I | 0.21 | 182 | | dSph | 2015 [16] |
| Tucana IV | 0.25 | 48 | | dSph | 2015 [16] |
| Reticulum III | 0.13 | 92 | | dSph | 2015 [16] |
| Tucana V | 0.03 | 55 | | dSph | 2015 [16] |
| Indus II | 0.36 | 214 | | dSph? | 2015 [16] |
| Cetus II | 0.03 | 30 | | dSph? | 2015 [16] |
| Horologium II | 0.09 | 78 | | dSph | 2015 [17] |
| Draco II | 0.04 | 20 | -2.9 | dSph | 2015 [18] |
| Sagittarius II | 0.08 | 67 | -5.2 | dSph | 2015 [18] |
| DES | - | 82 | | GC | 2016 [19] |
| Crater II | 2.2 | 117.5 | | dSph | 2016 [20] |
| Aquarius II | 0.32 | 108 | -4.2 | dSph | 2016 [21] |

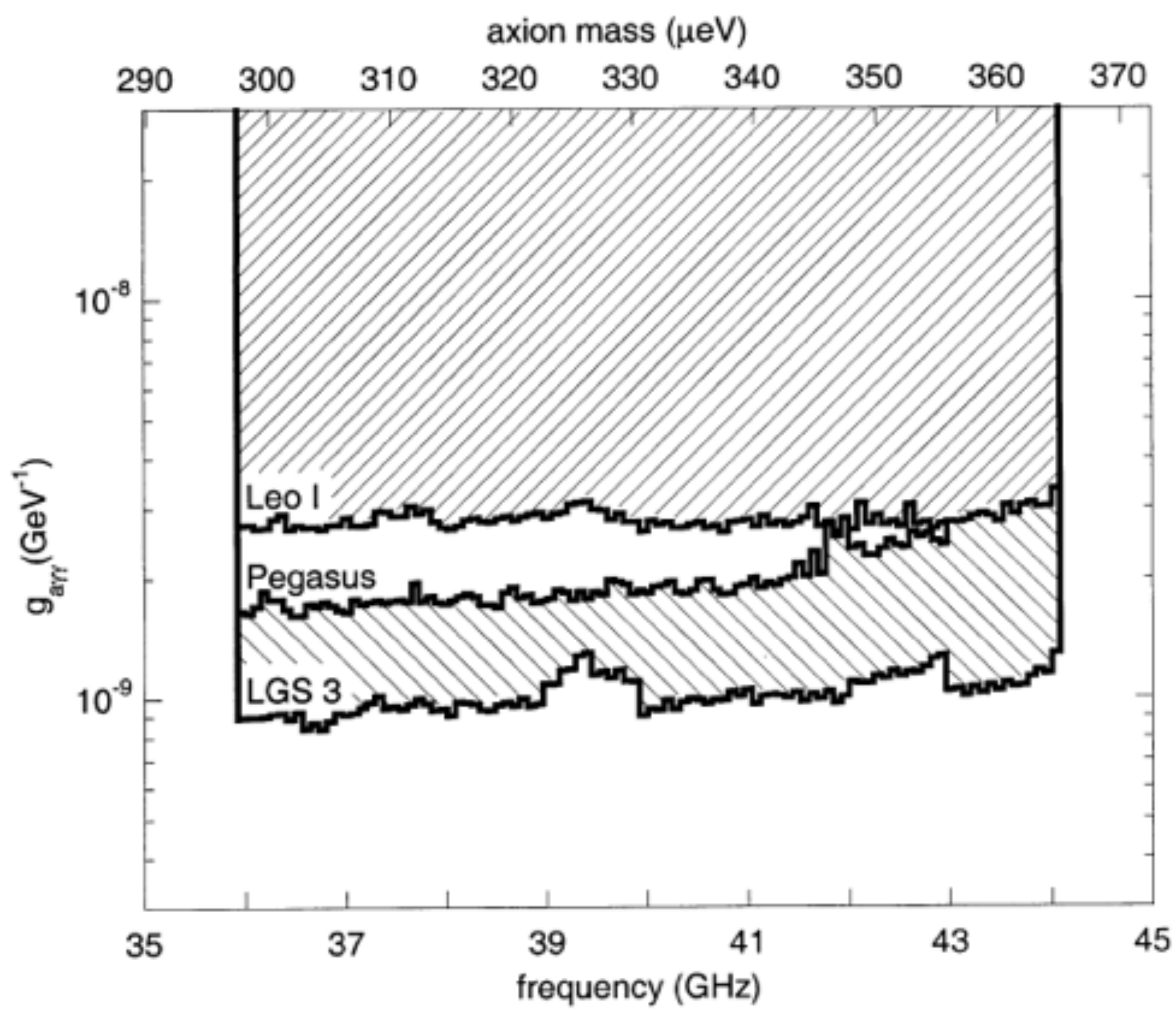
$$J_d \equiv \int d\Omega \int_{l.o.s.} \rho(\ell) d\ell$$




1 'Bootes I'
2 ‘Canes I'
3 'Canes II'
4 'Carina'
5 'Coma Berenices'
6 'Draco'
7 'Fornax'
8 'Hercules'
9 'Leo I’
10 'Leo II'
11 'Leo IV'
12 'Sculptor'
13 'Segue I'
14 'Sextans'
15 'Ursa Major I'
16 'Ursa Major II'
17 'Ursa Minor'
18 'Willman 1'

# Haystack observatory: 37m radiotelescope
# 36-44 GHz band, on/off 160 MHz bandwidth, 256 channels



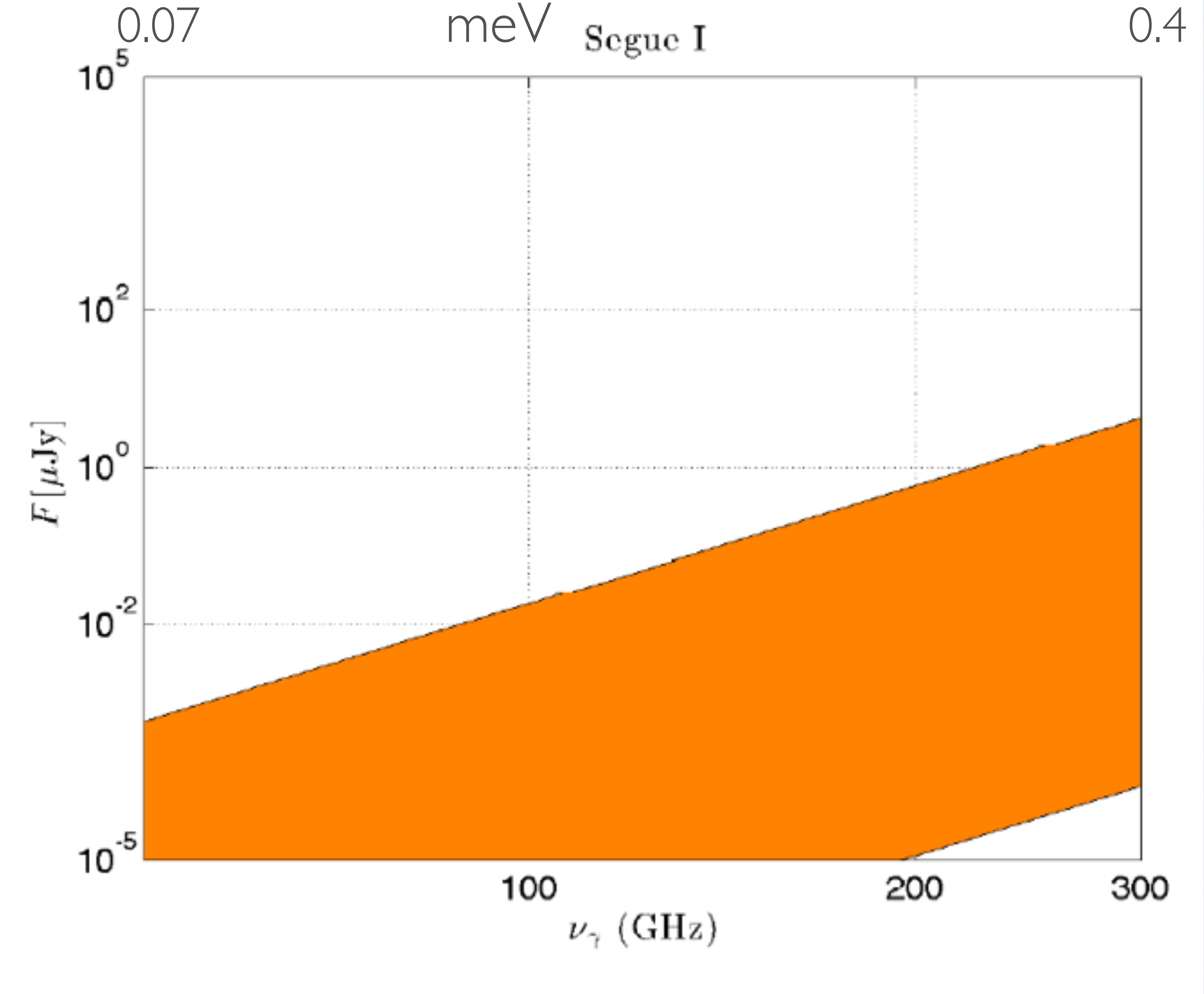




First limit derived by observing spontaneous decay

**Blout et al, 2001**

# Forecast: radio observations of dwarf spheroidal Milky Way satellites with resolution (1MHz) with large radiotelescope

$$\Phi = \frac{\nu}{\Delta\nu}\frac{2J_d}{4\pi}\frac{\Gamma_a}{m_a}$$




Integrated over a beam of 0.2°.

Occupation number not included

Phase I: background studies (since 2015)
First two campaigns: Radio background in the direction to satellite galaxies, Segue & Bootes

North:
- 6h observation, VLA L & Q band, 1.3-1.7 GHz, 40-50 GHz
- Signal lower than mJy in L band. Q band in data reduction

South:
- Time requested for Reticulum II, Parkes telescope

Goal of phase I: $g < 10^{-12}$ GeV$^{-1}$

Summary:

If axions are discovered with masses not much below meV, check spectral features in magnetic compact objects and search for potentially observable lines, most probably looking at our satellites