Radio Emission from Extrasolar Planets and the Astronomy & Astrophysics 2020 Decadal Survey Joseph Lazio



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# **Planetary Radio Emission**

Jupiter



### **Planetary Radio Emission**

Jupiter as an Extrasolar Planet



Radio Emission from Extrasolar Planets and the Astronomy & Astrophysics 2020 Decadal Survey

- Context and landscape
  - 2020 Decadal Survey in Astronomy & Astrophysics (Astro2020)
  - Exoplanet Science Strategy
- Magnetic Planets white paper
- Discussion

# **Recall Decadal Survey History**

stronomy and Astrophysics in the New Millennium

National Research Council

- 1964: Ground-based Astronomy: A Ten Year Program (Whitford) Recommended building more large optical telescopes including one in Chile QSOs had just been discovered
- 1972: Astronomy and Astrophysics for the 1970s (Greenstein)
  Recommended building the VLA, HST
  Astronomy satellites used to discover X-ray emission from stars
- 1982: Astronomy and Astrophysics for the 1980s (Field) Recommended building the Chandra X-ray satellite + VLBA Many galaxies observed to produce large amounts of IR emission

New Worlds,

New Horizons

- 1991: The Decade of Discovery in Astronomy and Astrophysics (Bahcall) Recommended building Spitzer and the Gemini telescopes + VLA expansion Existence of dark matter demonstrated
- 2001: Astronomy and Astrophysics in the New Millennium (McKee-Taylor) Recommended building JWST, ALMA First exo-planets discovered, first evidence of dark energy seen
- 2010: New Worlds, New Horizons in Astronomy and Astrophysics (Blandford) Recommended WFIRST, LSST







# Astro2020

#### http://sites.nationalacademies.org/SSB/CurrentProjects/SSB\_185159

Astronomy and Astrophysics Decadal Survey



Sign up for our astronomy mailing list:

Email Address

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Note from the co-chairs. Read here.

Survey Updates

- AAS town hall January 9 at 6:30 p.m. in Room 6B
- White paper deadline now February 19 at 5:00 p.m. ET
- White paper template posted
- Call for committee member nominations

We are requesting nominations to help identify qualified members of both the survey committee and future scientific and programmatic panels. If you know of individuals who you believe would be excellent candidates for participation, or if you would like to volunteer, please <u>fill out a nomination form</u>. We will accept nominations until January 22, 2019.

Highlighted Activities



#### Astro2020 Science White Papers I

- "White papers should:
  - 1. Identify scientific opportunities and compelling scientific themes for the coming decade, particularly those that have arisen from recent advances and accomplishments in astronomy and astrophysics;
  - 2. Describe the scientific context of the importance of these opportunities, including connections to other parts of astronomy and astrophysics and, where appropriate, to the advancement of our broader scientific understanding;
  - 3. While focusing on science, not specific missions or projects, describe and quantify the key advances in observation, measurement, theory, and/or computation necessary to realize the scientific opportunities within the decade 2020-2030 and beyond.

#### **Astro2020 Science White Papers II**

**Code phrase?** 

"White papers should [...]

3. While focusing on science, not specific missions or projects, describe and quantify the key advances in observation, measurement, theory, and/or computation necessary to realize the scientific opportunities within the decade 2020-2030 and beyond.

### **Science White Papers III**

From "New Worlds, New Horizons for RMS," N. Evans



#### Astro2020 Science White Papers IV

#### "White papers should [...]

- 3. While focusing on science, not specific missions or projects, describe and quantify the key advances in observation, measurement, theory, and/or computation necessary to realize the scientific opportunities within the decade 2020-2030 and beyond.
- Code phrase?
- Observing electron cyclotron maser emission from magnetic planets requires
  - Frequency  $\lesssim$  50 MHz
    - Driven by planet's magnetic field strength
  - High sensitivity, mJy or better
    - Extrapolation from solar system experience
  - Polarization desirable
    - Mechanism is intrinsically circularly polarized

# Astro2020 Science White Papers V

http://sites.nationalacademies.org/SSB/CurrentProjects/SSB\_185159

#### Astronomy and Astrophysics Decadal Survey





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**Highlighted Activities** 

/hite Paper Submissions (The submission deadline has been extended to Feb. 19, 2019)

#### From Decadal Survey Town Hall ...

- White paper deadline now
  February 19 at 5:00 p.m. ET
  Not required to submit at 4:59 p.m.
  ET
- Optional template posted Yes, it is in Word
- Importance of white papers as form of community input stressed
  - E.g., structure journal clubs around white papers
  - Anybody can submit a white paper
- Almost certain to be programmatic and state-of-the profession white papers
- White papers introduced in Astro2010

#### **Exoplanet Science Strategy**

he National | SCIENCES cademies of | ENGINEERING | MEDICINE

**Exoplanet Science Strategy** 

Download the report at nap.edu/25187

#ExoplanetScience Questions?: exoplanets@nas.edu

The NASA Transition Authorization Act of 2017 directed [NASA] to engage the National Academies of Sciences, Engineering, and Medicine in the development of a science strategy for the study and exploration of extrasolar planets in preparation for, and as an input to, the upcoming decadal surveys in astronomy and astrophysics and in planetary science.

# **Planetary Evolution**

**Exoplanet Science Strategy** 

The long-standing question of whether giant planets can form through disk instability as well as core accretion has given way to a more nuanced question of the accretion histories of these objects. ... A second question relates to the inflated radii of many hot Jupiters. The range of theories broadly bifurcates into those that provide an additional energy source over the lifetime of the planet, and those that trap in heat from formation and slow the planetary cooling process. Recent advances include applying statistical techniques to the full population of known hot Jupiters (Thorngren and Fortney, 2018), which conclude that Ohmic heating (Batygin and Stevenson, 2010) is the likely mechanism for transferring heat from the atmosphere into the interior. Modeling the magnetic environment of a close-in exoplanet is challenging and **poorly constrained by observations.** Magnetohydrodynamic models detailing the interactions between magnetic fields and the planet's atmosphere and interior are currently underdeveloped.

# What Makes a Planet Habitable?

**Exoplanet Science Strategy** 

In parallel with the advances in observations, the exoplanet, Solar System, and astrobiology communities have generated a more comprehensive picture of planetary habitability. ...

Many factors and interactions are now expected to impact planetary habitability. These include the following:

- The presence and distribution of liquid water oceans on the planetary surface ....
- The presence of a stable secondary atmosphere. ...
- The presence of tectonic or volcanic activity and weathering processes to replenish atmospheric loss (...), and buffer climate (...).
- The internal energy budget of a planet ....
- The presence and strength of a **global-scale magnetic field**, which depends on interior composition and thermal evolution (Driscoll and Bercovici, 2013).

There are important feedbacks identified between the processes listed above .... For example, the persistence of a secondary atmosphere over billion-year time scales requires low atmospheric loss rates, which in turn can be aided by the presence of a **planetary magnetic field** (Driscoll and Bercovici, 2013; Garcia-Sage et al., 2017; Dong et al., 2018).

# Magnetic Fields of Extrasolar Planets: Planetary Interiors and Habitability

#### Magnetic Fields of Extrasolar Planets: Planetary Interiors and Habitability

A white paper submitted to the National Academy of Science Committee on Exoplanet Science Strategy

J. Lazio<sup>1</sup> (Jet Propulsion Laboratory, California Institute of Technology) G. Hallinan (California Institute of Technology),

V. Airapetian (NASA/GSFC), D. A. Brain (University of Colorado, Boulder), C. F. Dong (Princeton University), P. E. Driscoll (Carnegie Institute for Science), J.-M. Griessmei**er** (LPC2E-Universitè d'Orlèans/CNRS, Station de Radioastronomie de Nançay, Observatoire de Paris), W. M. Farrell (NASA/GSFC), J. C. Kasper (University of Michigan), T. Murphy (University of Sydney), L. A. Rogers (University of Chicago), Alex Wolszczan (Pennsylvania State University), P. Zarka (Observatoire de Paris, CNRS, PSL), M. Knapp (MIT EAPS), C. R. Lynch (University of Sydney), J.D. Turner (University of Virginia)

- Scientific Background
- Planetary Interiors
- Planetary Habitability
- Progress in the Next Decade and Beyond

### Magnetic Fields of Extrasolar Planets: Planetary Interiors and Habitability

#### Magnetic Fields of Extrasolar Planets: Planetary Interiors and Habitability

A white paper submitted to the National Academy of Sciences Astro2020 Decadal Survey on Astronomy & Astrophysics

Thematic Area: Planetary Systems

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Jupiter's radio emission has been linked to its planetary-scale magnetic field, and spacecraft investigations have revealed that most planets, and some moons, have or had a global magnetic field. Generated by internal dynamos, magnetic fields are one of the few remote sensing means of constraining the properties of planetary interiors. For the Earth, its magnetic field has been speculated to be partially responsible for its habitability, and knowledge of an extrasolar planet's magnetic field may be necessary to assess its habitability. The radio emission from Jupiter and other solar system planets is produced by an electron cyclotron maser, and detections of extrasolar planetary electron cyclotron masers will enable measurements of extrasolar planetary magnetic fields. Key advances in the next decade would include the ground-based detection of the radio emission from Jovian-mass planets and laying the technological foundations for future space-based detections of the radio emission from lower mass planets.

Co-authors/cosigners welcome Cross-references important Are you writing a science white paper on related topic?

# Discussion

#### **Astro2020 Panel Nominations**

"We are seeking nominations for the survey committee and panels (note the panel structure is still being determined, but please nominate people suitable for potential science, program, as well as state of the profession panels). Consideration of nominations will begin January 22, 2019.

https://www.surveygizmo.com/s3/ 4703010/ASTRO-2020-Decadal-Survey-CALL-FOR-NOMS



Illustration of structure of previous Decadal Surveys; Astro2020 structure not yet determined.

# **Factors Affecting Habitability**

#### **Exoplanet Science Strategy**

