Jet Propulsion Laboratory
California Institute of Technology

PI LAUNCHPAD
VIRTUAL SUMMIT
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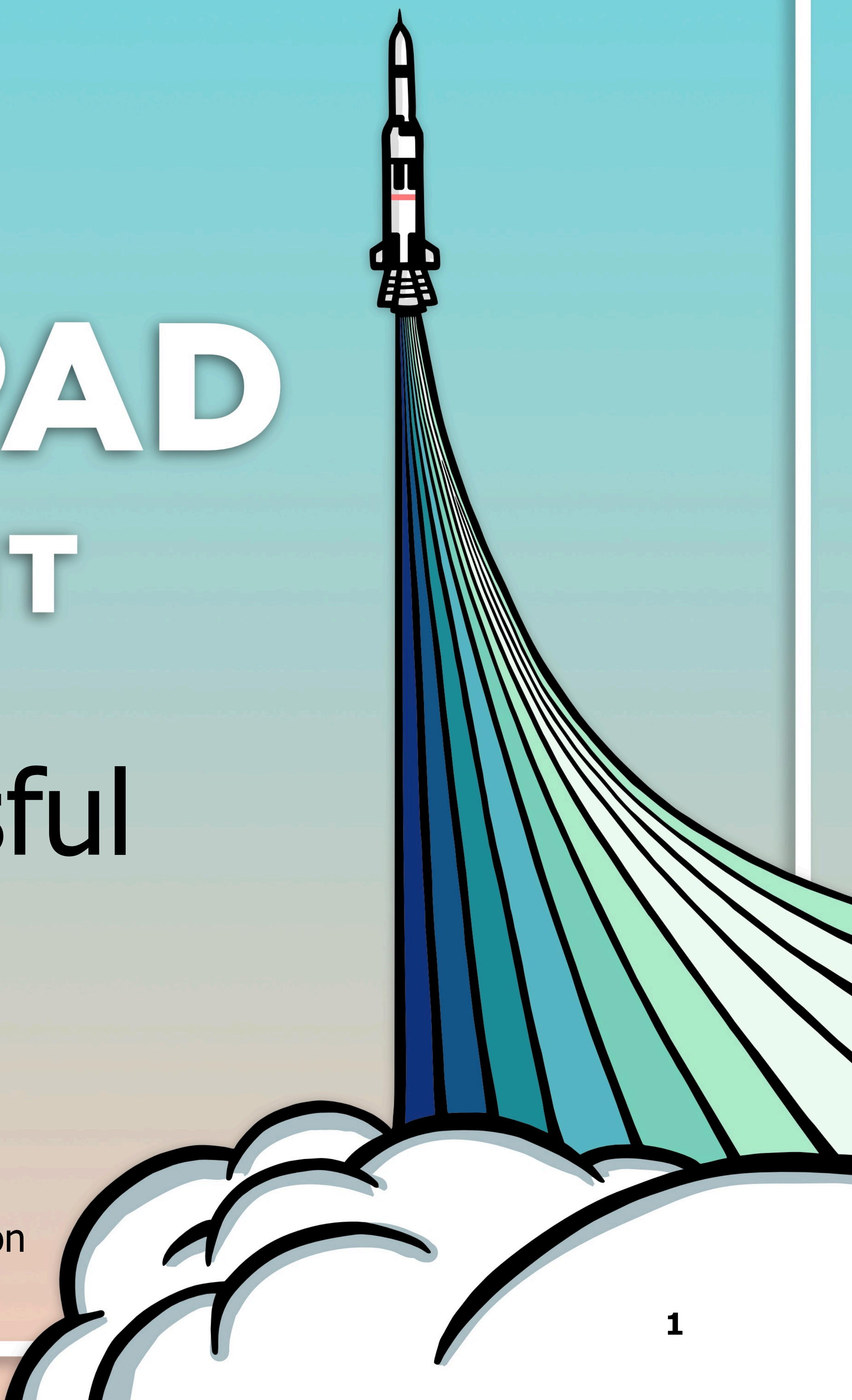
Examples of Successful Science Stories



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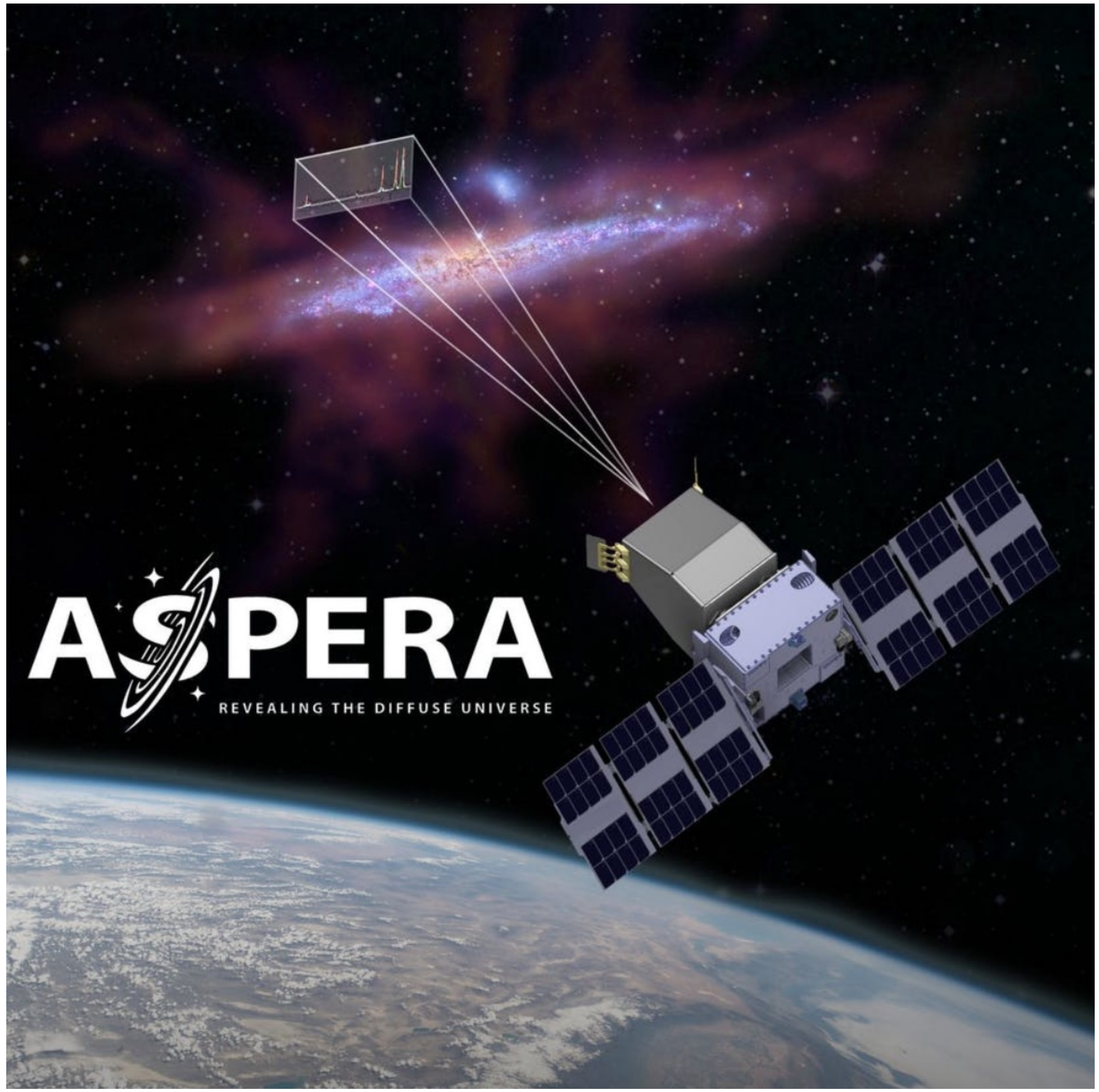
Agenda

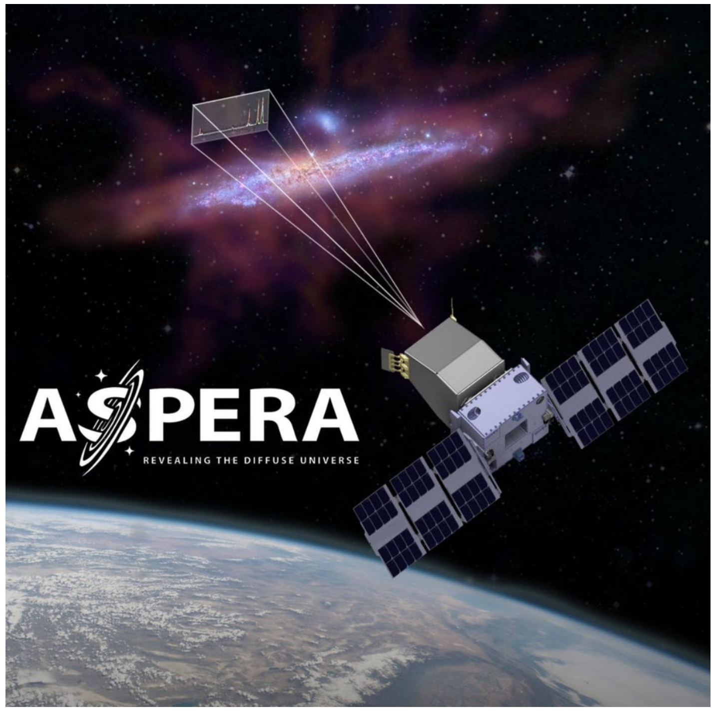
- Astrophysics / Universe – Aspera (Pioneer AO)
- Solar System – Psyche (Discovery AO)
- Earth Science – TEMPO (Earth Venture – Instrument AO) (partial)


ASPERA
REVEALING THE DIFFUSE UNIVERSE

Astrophysics / Universe - Aspera

High-level mission description

The Aspera Mission seeks to solve the mystery of how galaxies form by producing the first maps of the mysterious “warm-hot” phase of gas that surrounds galaxies. This gas is really hot (300,000 degrees) and accounts for more mass than the stars within the galaxy itself, but has been infrequently detected before now and never mapped around nearby galaxies. Understanding how this gas flows in and out of galaxies is crucial for understanding how galaxies evolve over time. Aspera detects this gas by observing ionized Oxygen in the extreme UV bandpass.



First sentence describes the mission without acronyms of jargon

Second sentence describes what it is

Third sentence describes why we care

Astrophysics / Universe - Aspera

Science Questions

1. Is the presence of a warm-hot halo ubiquitous for nearby star forming galaxies?
2. Is the warm-hot gas volume-filling or filamentary in the halos of star forming galaxies and how much is there?
3. Does the warm-hot gas come from outflows from the galaxy disk?

Traces to: New Worlds, New Horizons in Astronomy & Astrophysics (2010)

How do baryons cycle in and out of galaxies and what do they do while they are there?

This makes the science question two questions

Astrophysics / Universe - Aspera

Hypotheses

1. OVI emission (to around 4.5e-19 ergs s-1 cm-2 arcsec -2) is ubiquitous within 10 arcmin of a galaxy
2. OVI emission has bright filamentary structure in an otherwise very faint halo
3. The velocity signature of OVI emission will indicate an outflowing ‘super-bubble’ feedback-driven gas

Same

Same

Predictions

1. OVI emission (to around 4.5e-19 ergs s-1 cm-2 arcsec -2) is ubiquitous within 10 arcmin of a galaxy
2. We expect the structure of the emission to be similar to the simulations
3. The velocity signature of OVI emission will indicate an outflowing ‘super-bubble’ feedback-driven gas

Astrophysics / Universe - Aspera

Mission Objectives

1. Determine the prevalence of circum-galactic warm-hot gas in nearby galaxies
2. Determine if the spatial distribution of large-scale warm-hot gas flows is significantly filamentary in galaxies with detections in Objective 1
3. Determine if the abundance and kinematics of warm-hot phase baryons in the circum-galactic medium is consistent with 'super-bubble' feedback models in galaxies with detection in Objective 1

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Be careful not to have too many objectives. Each objective has its own requirements which drive cost, complexity and risk.

Astrophysics / Universe - Aspera

Why do I care?

We know galaxies need a continuous supply of new gas to keep making stars. This gas supply comes from farther out in space, but is also mixed with outflowing gas blown out of the galaxy from supernovae and over energetic events. The gas-rich halo around galaxies is thought to be even more massive than the galaxy itself and likely plays a key role in the evolution and fate of the galaxy (i.e. will it keep making stars?). The structure of this halo might be smoothly varying with decreased intensity and density as distance from the galaxy increases. Or it may be more structured, with filaments and interacting flows. Aspera measures a key component of the gas-rich halo that has never been systematically studied before.

Explains what the mission does

Need a succinct statement about why this is important

Astrophysics / Universe - Aspera

Why now / Why has this never been done before?

SmallSat spacecraft and busses are significantly improved in the last ten years and now have enough reliability and stability to support astrophysics investigations. UV detectors, mirror coatings, and gratings performance have advanced to the point where a small mirror can provide the same sensitivity as an explorer mission from a decade ago. Observations of OVI emission previously were costly and difficult to conduct (only one mission has made observations of nearby galaxies), and are now achievable without waiting for a flagship or probe class mission. Data from Aspera will also help inform simulations and designs for future mission concepts (LUVOIR and a variety of probes).

Describes what technologies have improved to now make this mission possible

Shows how this mission could support future NASA missions


PSYCHE
JOURNEY TO A METAL WORLD

Solar System - Psyche

High-level mission description

Our solar system offers few types of target bodies that await first time exploration. Every world explored so far by humankind has a surface of ice or rock. Sensitive measurement techniques let us infer remarkable interiors. Within terrestrial planets, including Earth, we infer remote metallic cores, unreachably deep beneath the rocky mantles and crusts.

Psyche explores the solar system's only accessible, exposed planetary core – directly measuring what is deep inside all planets to reveal how they accrete, differentiate, and collisionally re-form.

Sentence describes the mission without jargon

Sentence describes why we care

What about the Outer Planets? Be careful with grandiose sensationalistic statements

Could be stronger if the second paragraph came first

Solar System - Psyche

Science Questions

1. What were the initial stages, conditions, and processes of solar system formulation and the nature of the interstellar matter that was incorporated? *
2. What governed the accretion, supply of water, chemistry, and internal differentiation of the inner planets and the evolution of their atmospheres, and what roles did bombardment by large projectiles play? *
3. Understand how and when planetesimals were assembled to form planets. *
4. Did asteroid differentiation involve near-complete melting to form magma oceans, or modest partial melting? *

Quotes directly from the Decadal Survey

These were all listed as science goals

* Traces to Visions and Voyages for Planetary Science in the Decade 2013 – 2022 (2011)

Solar System - Psyche

Hypotheses

1. Was it a molten core of a differentiated planetesimal(?)
2. Did it instead accrete from primordial highly reduced metallic materials (?)

Predictions

1. If Psyche's structure predominately reflects solidification from a liquid it will have a radial density structure, while if it was significantly disrupted and/or was never molten it should have a heterogeneous density structure. Further, if it was once molten, its nickel, sulfur, and magnetic field characteristics may be able to determine whether it solidified from the inside out or the outside in.
2. If it never melted and differentiated but instead accreted as is, it will lack magnetic fields and large Ni variations, and its silicate fraction will be intimately mixed with the metal phase.

Science predictions

Hypotheses and predictions were listed as science objectives

Hypotheses written as questions

Predictions were buried in the "science objectives"

Solar System - Psyche

Mission Objectives

1. Determine whether Psyche is a core, or if it is primordial unmelted material
2. Determine the epoch of formation of Psyche by measuring the relative ages of regions of its surface
3. Determine whether small metal bodies incorporate the same light elements into the metal phase as are expected in the Earth's high-pressure core
4. Determine whether Psyche was formed under more oxidizing or more reducing conditions than Earth's core
5. Characterize Psyche's topography

Mission objectives are clear

An objective that starts with the word "characterize" is difficult to determine success criteria

Be careful not to have too many objectives. Each objective has its own requirements which drive cost, complexity and risk.

Solar System - Psyche

Why do I care?

Missions studying Vesta and the large Galilean and Saturnian satellites (and now, Ceres), have revealed their complex exteriors but have only hinted at the details of their interiors. Even the MESSENGER mission to Mercury, the lunar missions, and the missions to Mars have just begun to remotely observe the interiors of those bodies, revealing tantalizing hints of their complex core structures, but despite decades of investigation, there are many unanswered questions about the composition and formation mechanisms for planetary cores.

Psyche is the ultimate laboratory of early impacts and differentiation, with the ability to arbitrate between competing models for early solar system materials and processes.

Defines the problem

Begins to explains why we care

Could use a stronger statement about why we care

Connections to other NASA missions can enhance the why do I care

Solar System - Psyche

Why now / Why has this never been done before?

Recent analytical and theoretical developments make this mission a timely investigation. New meteorite geochronology reveals that metal cores formed within the solar system's first half million years, and that differentiation occurred in even very small bodies – a result confirmed by Dawn at Vesta. Meteorites also reveal that many differentiated bodies, including iron meteorite parent bodies, produced magnetic dynamos [Tarduno et al., 2012; Weiss & Elkins-Tanton, 2013; Bryson, 2014]. And high-energy impacts were ubiquitous in the early solar system, so planetary cores likely formed and reformed repeatedly.

Starts to address why now

Need a strong statement for why now and why this has never been done before

Earth Science - TEMPO

High-level mission description

The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument measures pollution of North America, from Mexico City to the Canadian tar/oil sands, and from the Atlantic to the Pacific, hourly and at high spatial resolution. TEMPO spectroscopic measurements in the ultraviolet and visible wavelengths provide a tropospheric measurement suite that includes the key elements of tropospheric air pollution chemistry. Measurements are from geostationary orbit, to capture the inherent high variability in the diurnal cycle of emissions and chemistry. A small product spatial footprint resolves pollution sources at a sub-urban scale. Together, this temporal and spatial resolution improves emission inventories, monitors population exposure, and enables effective emission-control strategies.

First sentence describes the mission without jargon

Second sentence describes the instrument

Careful not to get too detailed

Last sentence describes why we care

Earth Science - TEMPO

Science Questions

1. What are the temporal and spatial variations of emissions of gases and aerosols important for air quality and climate?
2. What are the physical, chemical, and dynamical processes that transform tropospheric composition and air quality over scales ranging from urban to continental, diurnally to seasonally?
3. How does air pollution drive climate forcing and how does climate change affect air quality on a continental scale?
4. How can observations from space improve air quality forecasts and assessments for societal benefit?
5. How does intercontinental transport affect air quality?
6. How do episodic events, such as wild fires, dust outbreaks, and volcanic eruptions, affect atmospheric composition and air quality?

Be careful not to have too many science questions. Each question has its own objectives which, in turn, has requirements which drive cost, complexity and risk.

Earth Science - TEMPO

Why do I care?

TEMPO's hourly measurements allow better understanding of the complex chemistry and dynamics that drive air quality on short timescales by capturing rapidly varying emissions and chemistry important for air quality.

Planning is underway to combine TEMPO with regional air quality models to improve EPA air quality indices and to directly supply the public with near real time pollution reports and forecasts through website and mobile applications.

Need a more succinct statement about why this is important

Explains what the mission does

Partially explains why we care

Final Thoughts

- Don’t make reviewers “hunt” for the mission description, the science questions, proposed hypotheses & predictions, mission objectives, the why do I care and the why now statements
  - Consider using call-out boxes for each of the above items to clearly address them

- For each section in a proposal, try to answer the question in the first 1 or 2 sentences, then expand for clarification

- Try to show how your science will enhance data sets from current NASA missions and/or help guide the development of future NASA missions

- Be concise