

# Inside the Zodiac

*A 10-minute planetarium mini-show*

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[About this show](#)

[In one Word...](#)

[In one Sentence...](#)

[In one Paragraph...](#)

[Storyboard](#)

[Setup](#)

[Script Notes](#)

[Script](#)

[Introduction—The Zodiac](#)

[What's In Your Sign: Planets](#)

[What's In Your Sign: Exoplanets](#)

[Kepler's Planet-Finding Mission](#)

[Conclusion](#)

[Appendix: Sample objects in the campaign fields](#)

[Campaign fields and objects](#)

[Definitions](#)

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## About this show

### In one Word...

Discovery

### In one Sentence...

The zodiac constellations have always been special and the Solar System planets are found there, but when the Kepler spacecraft could not keep pointing at its original target field, then the clever engineers and scientists figured out how to keep Kepler pointed steady at these rich areas of the Universe to make new discoveries.

### In one Paragraph...

Since time immemorial, our ancestors have noticed and identified the signs of the zodiac. After realizing the zodiac constellations have a special significance as the home of the planets, the Sun, and then Moon, people have kept a close eye on them, using them as seasonal markers. But when the Kepler Spacecraft needed a new mission, scientists and engineers pointed it towards the zodiac; now astronomers are getting unprecedented views into the zodiac, which may unlock new discoveries about our Solar System, our Galaxy, and our Universe.

## Storyboard

1. What is the zodiac? The ecliptic?
2. What's in your sign: planets
3. What's in your sign: exoplanets
4. Kepler's planet-finding mission
5. What's in your sign: K2 campaign objects

## Setup

Aries high in sky, e.g. winter solstice 9 pm local time.

## Script Notes

[VE=Visual Effect] [Blue text=narration available pre-recorded]

# Script

## Introduction—The Zodiac

[VE - Image: Title—Inside the Zodiac]

Welcome to the planetarium. Free to ask questions during this show that is titled *Inside the Zodiac*.

Sometimes people ask, “What’s your sign?” But we are concerned with “What’s *in* your Sign?” Your zodiac sign, in particular.

But before we get to what’s *in* your sign, let’s tackle that first question: ***What does it mean when someone asks, “What’s your zodiac sign?” or “What’s your sign?” [Accept any answers...it may mostly be about astrological significance.]***

I really don’t know anything about the *astrology* of your sign, but we can explore a lot in the *astronomy* of your sign. Your zodiac sign is supposed to be the constellation, or the pattern of stars, that the Sun appeared in at the time of your birth.

**[VE - Make signs of the zodiac appear one by one in order, starting with Aries with a 1–2 second delay between each appearance. Have constellation labels on. Keep them on as it progresses so all 13 (including Ophiuchus) are on by the end. Do not show constellation boundaries just yet.]**

***If you know what your zodiac sign is, and you see your sign in the sky, please feel free to point to it where it is in the sky. In fact, you can stand and point to it if you like.***

[VE - Image: text=zodiac]

[VE - Show ecliptic and ecliptic label]

Throughout the year, as Earth orbits the Sun, the Sun *appears* to move in order through each of 13 constellations. We are seeing them in the sky now. These constellations that the Sun passes through are called the **zodiac** constellations. Notice how they trace a nice line in the sky? That’s because as the Earth orbits the Sun, the Sun’s apparent path in the sky traces a line called the **ecliptic**. So the zodiac is very much connected with the ecliptic—that path in the sky the Sun seems to follow as viewed from Earth.

***Any questions so far?***

[VE - Bring Ophiuchus to the sweet spot high in the sky, with outline off initially]

You may have noticed the Sun’s path along the ecliptic goes through one constellation that is not one of the 12 signs of the zodiac most people know.

[VE - Display zodiac constellation boundaries, but not Ophiuchus yet]

Look at the boundaries of the constellations.

***Notice there's a gap that the Sun passes through between Scorpius and Sagittarius from late November to mid-December (officially Nov. 29–Dec. 17)? Please point to that place in the sky if you see it.***

That's where the constellation Ophiuchus fits in.

**[VE - Bring up Ophiuchus constellation boundary]**

**[Optional: if someone asks why the ecliptic months do not match their sign, run time backwards 2,000 years with the zodiac constellations and the ecliptic on.]**

You may have noticed that your sign appears “off” from the dates you know. For example, Sagittarius is running December to January instead of November to December. That's because those dates were set 2,000 years ago. If we go back in time 2,000 years, we'll see the constellations shift over. This is because the Earth wobbles as it rotates—like a spinning top—and that wobble makes Earth's tilt shift. That change shifts our view of where the Sun appears against the background constellations. This wobble effect is called “precession.” So, 2,000 years ago, the Sun *was* in Sagittarius from November to December, but not today.

**[Return to present day. End optional section.]**

## **What's In Your Sign: Planets**

So, now to the question: What's *in* your sign?

**[VE - Turn planet labels on]**

There may be the Sun, Moon, or planets in your zodiac sign.

***Are there planets in your sign?***

If you see a planet or the Sun or Moon in your sign please point to it and say its name.

It turns out *every* planet, the Sun, and the Moon go through each sign sooner or later.

**[VE - Show planets moving at accelerated speed through one or more years. Have labels on and point out the Sun, Moon, a few of the planets]**

All the planets' orbits are not in the same plane as Earth's orbit, but they are all not very far from the ecliptic, so they all pass through the signs of the zodiac. You're seeing a very fast time-lapse view of how the planets move—an entire year in 90 seconds.

***Can you see a planet in your sign? Please call it out if you see a planet go in your sign.***

***Any questions about how planets move?***

### **What's In Your Sign: Exoplanets**

Here's a another question:

***Are there any planets in your zodiac sign, but outside the Solar System?***

**[VE - Mark stars with exoplanets]**

Here are stars with known **exoplanets**. The word "exoplanet" is short for "extrasolar planet," which means planets outside our Solar System.

***Do you see any stars with exoplanets that are in your Sun sign?  
If you see more than one, about how many do you see in your sign?***

**[VE - Rotate the sky 1 complete rotation so all of the zodiac constellations appear.]**

***If you have an estimate about how many exoplanet systems you count in your sign, call that number out loud if you like.***

### **Kepler's Planet-Finding Mission**

**[VE - Go to August 1, around 6:30pm local daylight time. This is when the Kepler field of view is just above the eastern horizon]**

The single program that has discovered the most planets of all is NASA's Kepler Mission. It discovered over 4,000 planets candidates by a method known as the transit method.

**[VE - Video: Kepler spacecraft, field of view, light capture, and transit light curve]**

The Kepler Space Telescope can sense very tiny changes in the brightness of a star. Actually *thousands* of stars simultaneously. It's target area of sky during its primary mission was not in a constellation of the zodiac. It was looking at over 150,000 stars in this area in the constellations Lyra (the Harp) and Cygnus (the Swan). It was looking for exoplanets that can't be seen directly. If an exoplanet travels in front of a star, that event is called a transit, and the planet blocks a tiny amount of the star's light. Kepler is so

sensitive, it can detect those drops in brightness. In a nutshell that's how Kepler discovers exoplanets. Kepler is specifically hunting for exoplanets that might have liquid water and possibilities for life.

**[VE - Image: Reaction Wheel OR Optional Video: Reaction Wheel]**

To keep the Kepler telescope pointed very precisely on its target, it uses reaction wheels like the one you see here, a type of fast spinning gyroscope. During its primary mission, Kepler collected data for a full four years. Over time, Kepler lost the use of two of its four reaction wheels, and you need at least three for precise pointing. When that happened everyone thought Kepler was finished. But Kepler engineers and scientists came up with a really ingenious plan for giving Kepler a second mission. By changing Kepler's target area to a position along the ecliptic, in a constellation of the zodiac, pressure from the solar wind that would normally push the telescope off target could be made very small. And that small pressure is enough to act as a third gyroscope to keep the telescope precisely on target. So Kepler has a new mission. It's called *K2*. And it is targeting areas along the ecliptic where your zodiac sign is!

**[Optional: VE - Video: K2]**

*K2* is still searching for exoplanets, so there may be many more exoplanets that are discovered in your zodiac sign. But Kepler will also study other celestial objects. Star clusters, gas clouds, and galaxies are all objects that astronomers are selecting as targets for study by Kepler.

**[VE - Overlay of Kepler campaign fields on the sky, numbered and with dates of observation. Show zodiac constellations also.]**

These are the areas Kepler plans to target and the approximate dates it will do the targeting.

***Do you see one that's in your sign? Would you like to know what kinds of astronomical objects are in your zodiacal sign?***

**[Encourage audience members to suggest their sign to see what types of objects Kepler will target. With each of the fields, show where the object is in the sky (circle it), show a telescope view of the object, and describe briefly what it is. Don't expect to do them all. Just whatever you have time for. See the appendix for a listing of the constellation, the Campaign Field Number, and sample object(s).]**

**Conclusion**

Under the *K2* Mission Kepler has new life, and will be looking in our Galaxy, out of our Galaxy and everywhere in between, looking for new exoplanets, stars, clusters, other galaxies, and more!

***Any last questions....?***

For more information, please visit the Kepler website at <http://kepler.nasa.gov>.

Thanks for coming to our show today. May you know not only what your sign is, but some of the exciting science K2 will explore *in* your sign.

## Appendix: Sample objects in the campaign fields

### Campaign fields and objects

**Campaign: #0**

**Constellation(s):** Gemini, near Taurus

**Objects:** M35—Open Cluster, 2800 LY away, almost as large as full moon. Also open clusters NGC 2158 and NGC 2304. Galactic anticenter.

**Campaign: #1**

**Constellation(s):** Leo, Virgo

**Objects:** North Galactic cap-looking nearly straight up out of the Galaxy, rich in external galaxies in the vicinity of the Virgo Cluster of galaxies; K2 will search for supernovae in hundreds of galaxies simultaneously. Example: M61

**Campaign: #2**

**Constellation(s):** Scorpius

**Objects:** Close to the direction of the Galactic center, a rich star forming region in the Milky Way. Globular clusters M4 and M80 located in the halo of our Galaxy, tens of thousands of light years distant, have thousands of very old, metal poor stars. The brightest x-ray source in the sky, Scorpius X-1. Mars will cross the field of view. More on M80: ~30,000 light-years away, ~95 light-years wide, several hundred thousand stars. Globular clusters are particularly useful for studying stellar evolution, since all of the stars in the cluster have the same age (about 15 billion years), but cover a range of stellar masses. M80 contains a relatively large number of blue stragglers, stars that appear to be much younger than the cluster itself. These stars may have lost part of their outer layers due to close encounters or collisions with other cluster members.

**Campaign: #3**

**Constellation(s):** Aquarius, near Capricornus

**Objects:** Mars, Neptune. South Galactic cap, opposite direction of Campaign 1. Monitor thousands of external galaxies and detect supernova outbursts from their beginning. As in all campaigns, K2 searches for exoplanets of nearby low-mass M class stars.

**Campaign: #4**

**Constellation(s):** Taurus

**Objects:** Pleiades, Hyades, with hundreds of bright and nearby stars, are the two most famous and brightest open stars clusters in the sky. The Pleiades, or the seven sisters, is ~400 LY away and the Hyades is ~150 LY away. Both promise to be gold mines of science for both stellar astrophysics as well as exoplanet discovery. Nearby exoplanets

discoveries are likely to be prime targets for follow-up by the James Webb Space Telescope.

**Campaign: #5**

**Constellation(s):** Cancer

**Objects:** The Beehive cluster (M44) and M67, open star clusters. M44 is ~600 LY away and located in the constellation Cancer. M67 is farther away at ~3000 LY, but is of great interest because it has mostly stars with age and metal content similar to our Sun.

**Campaign: #6**

**Constellation(s):** Virgo, near Libra

**Objects:** NGC5634 globular cluster

**Campaign: #7**

**Constellation(s):** Sagittarius, near Capricornus

**Objects:** M75 globular cluster

**Campaign: #8**

**Constellation(s):** Pisces

**Objects:** M74, face-on spiral galaxy, ~100 billion stars, ~32 million light-years away, with two clearly defined spiral arms, an archetypal example of a Grand Design Spiral Galaxy. The large angular size of the galaxy and its face-on orientation make it ideal for study of spiral arm structure and spiral density waves.

**Campaign: #9**

**Constellation(s):** Sagittarius

**Objects:** Milky Way galaxy center. The Lagoon Nebula (M8) is a giant interstellar cloud, emission nebula, H II region. Also M28 globular cluster, ~17,900 LY away, 551,000 solar masses, ~12 billion years old. And M22, only ~10,600 light-years away, ~100 LY across, one of only four globulars known to contain a planetary nebula (GJJC1) estimated to be a mere ~6,000 years old.

## **Definitions**

### **Star groupings**

- Constellation—an area of the sky with a pattern of stars often seen as a picture of an object, person, or animal.
- Open star cluster—a loose group of dozens to hundreds of stars, usually very young stars
- Globular star cluster—spherically-shaped, gravitationally bound group of stars with tens of thousands to several million stars—usually very old stars—located in the galactic “halo” of our Milky Way galaxy
- Galaxy—a massive, gravitationally bound system of stars, gas, dust, and dark matter, containing between ten million to one hundred trillion stars.

### **Galactic directions**

- Galactic anticenter—the direction in the sky directly opposite the center of the Milky Way Galaxy.
- Galactic cap—area on the sky looking nearly straight up (or down) out of the Milky Way Galaxy.