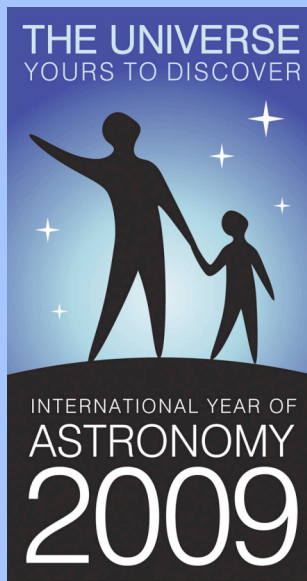



Creative Responses to the End of the World



Bill Harris, McMaster University

December 3, 2009



"This is the year in which we wish everyone on Earth thinks at least once about the wonders of the sky and hears or reads about astronomy's contribution to culture, history, our latest discoveries, and future prospects."

Catherine Cesarsky

President, International Astronomical Union



Guido van der Werve (2007)
The day I didn't turn with the world



Royden Rabinowitch
Bell for Kepler
IQC (U. Waterloo)



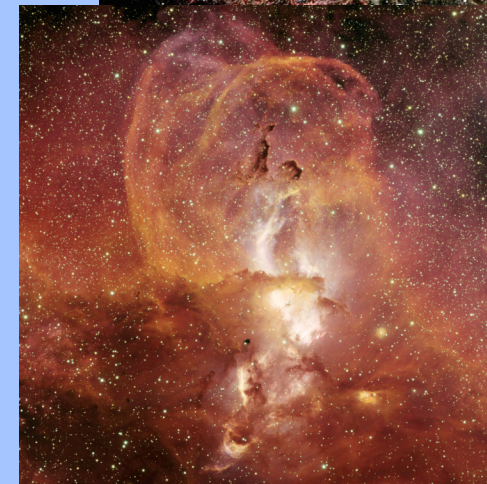
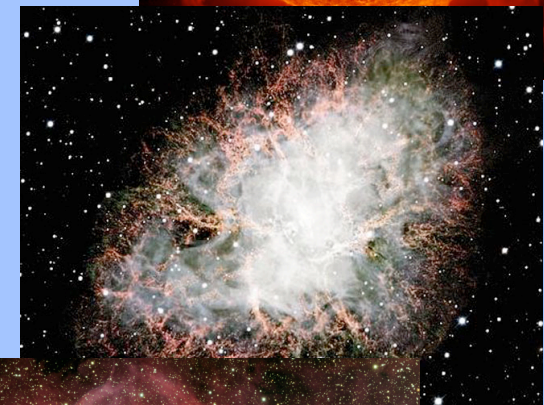
Artistic and humanist responses to discoveries about the universe have been consistently strong ever since Galileo

... but **which** discoveries or concepts create the most frequent reactions? Which of Galileo's findings 400 years ago created the most impact in those terms?

Which modern discoveries generate the most response?

Prominent findings from present day astrophysics:

We are stardust (or nuclear waste).



Periodic Table of the Elements

1	IA	1	H	2	O	2	He
2		3	Li	4	IIA	4	Be
3		11	Na	12		10	Ne
4		19	K	20		18	Ar
5		37	Rb	38		36	Kr
6		55	Cs	56		54	Xe
7		87	Fr	88		86	Rn

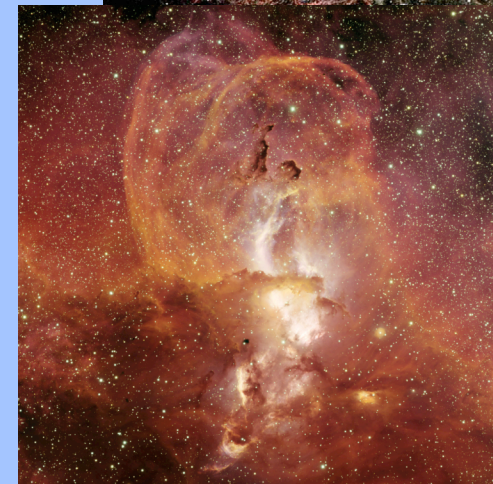
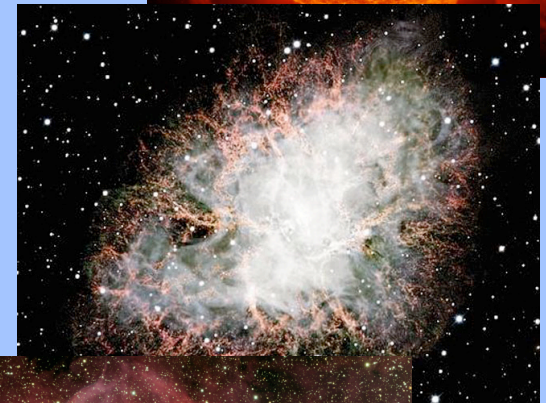
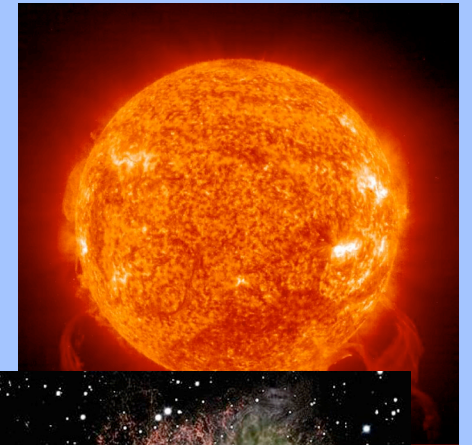
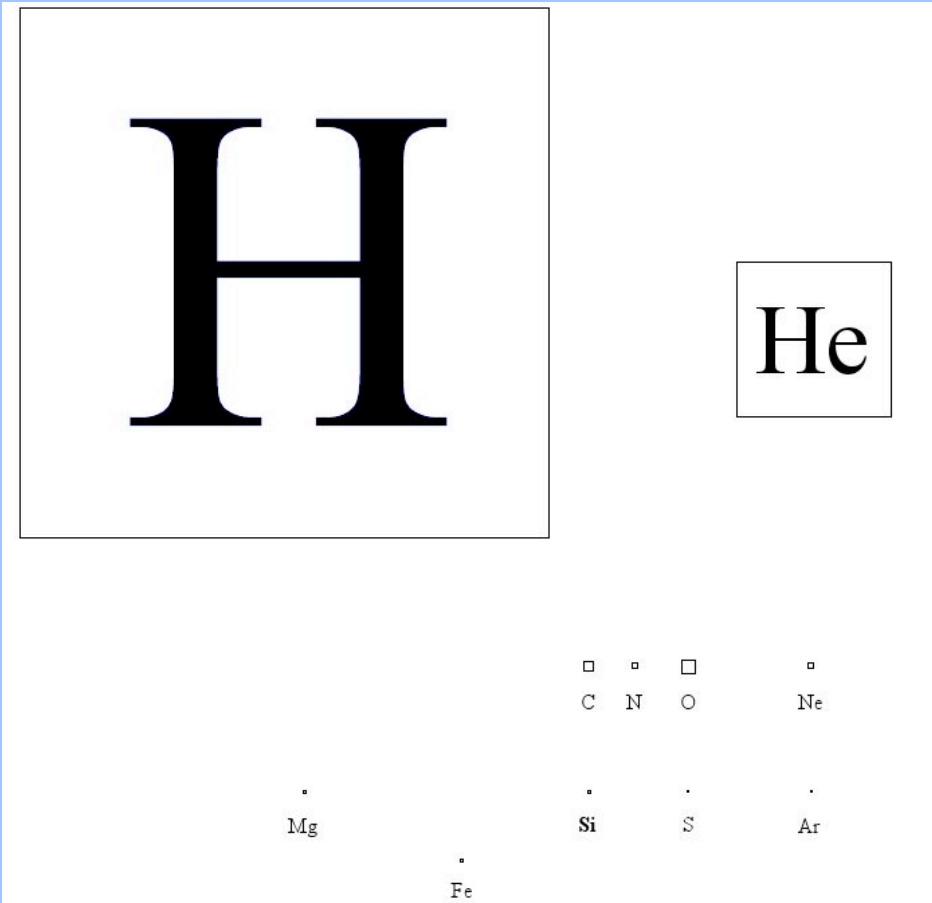
3	IIB	5	B	6	C	7	N	8	O	9	F	10	Ne																								
2		13	Al	14	Si	15	P	16	S	17	Cl	18	Ar																								
3		19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
4		37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
5		55	Cs	56	Ba	57	*La	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
6		87	Fr	88	Ra	89	+Ac	104	Rf	105	Ha	106	Sg	107	Ns	108	Hs	109	Mt	110	110	111	111	112	112	113	113										

* Lanthanide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

+ Actinide Series

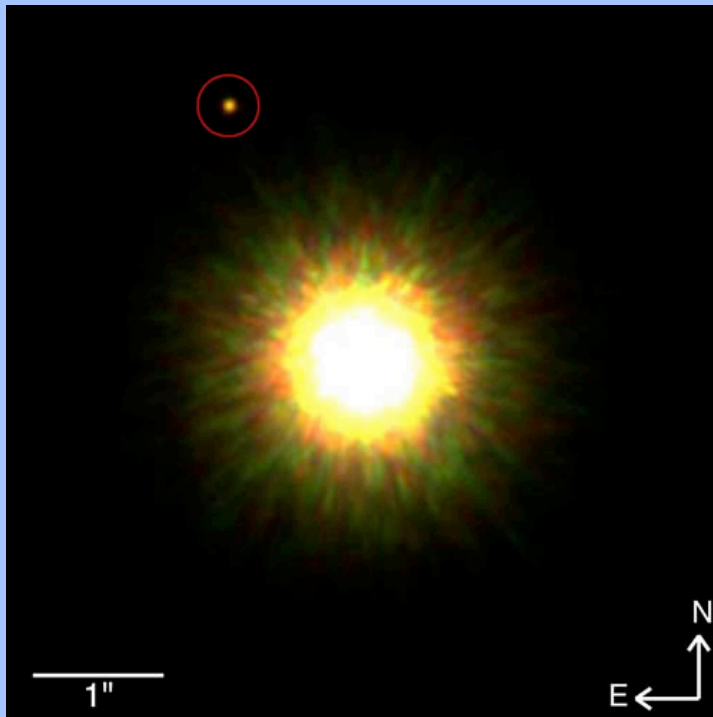
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



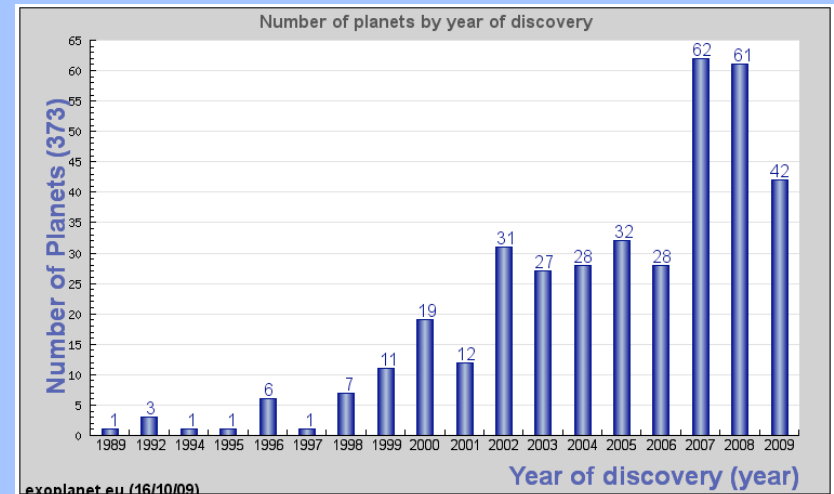
(An astrophysicist's periodic table of the elements)

Courtesy David Kahl, McMaster University

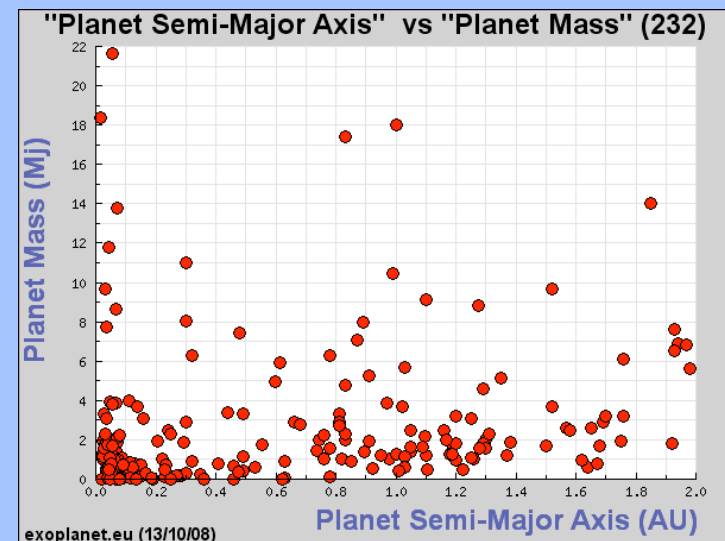
We have evidence for more than 400 planets around nearby stars.



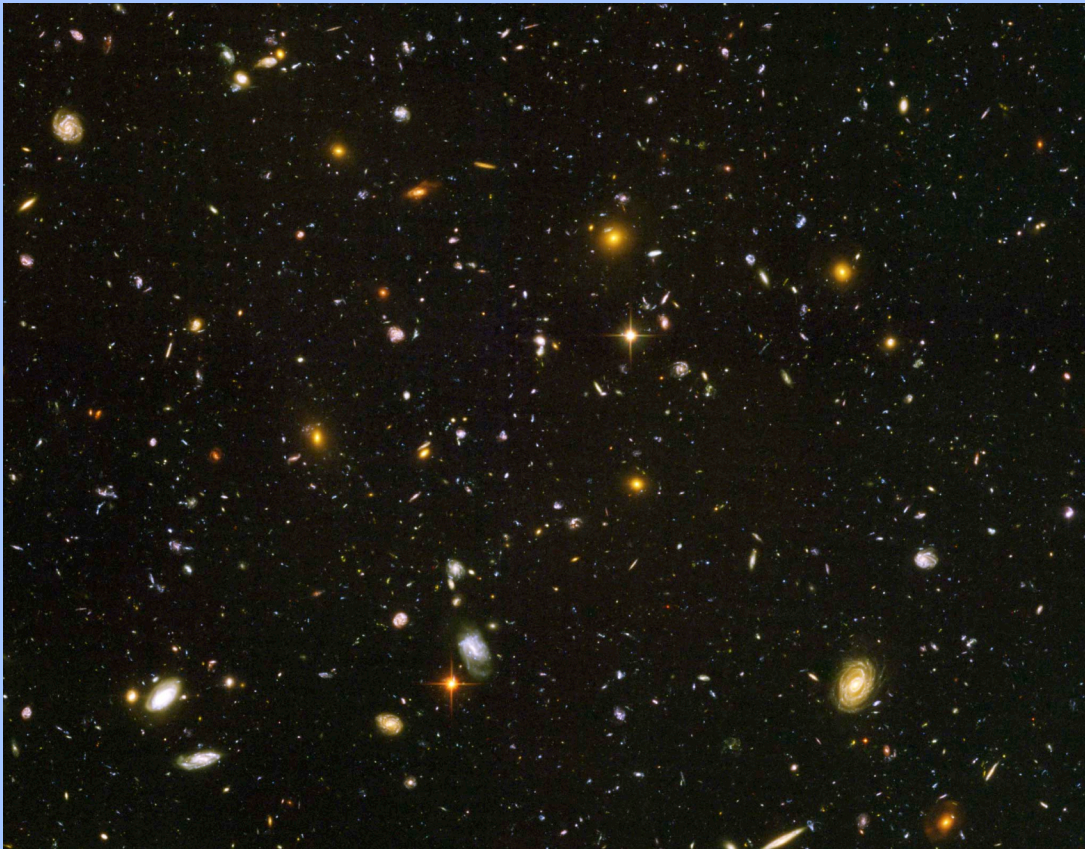
Gemini Observatory (Sept 2008)



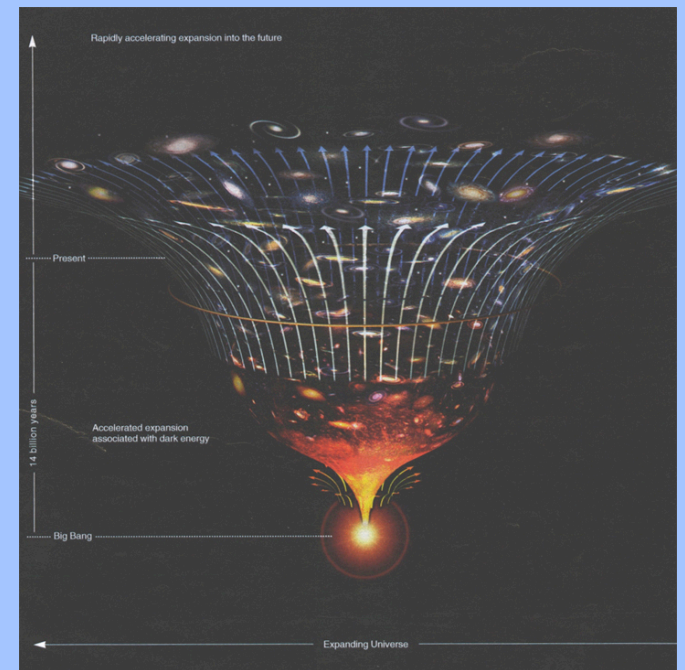
Jean Schneider (Oct 2009)



*The expansion of the universe is accelerating,
and the end of the visible universe as we
know it is coming.*

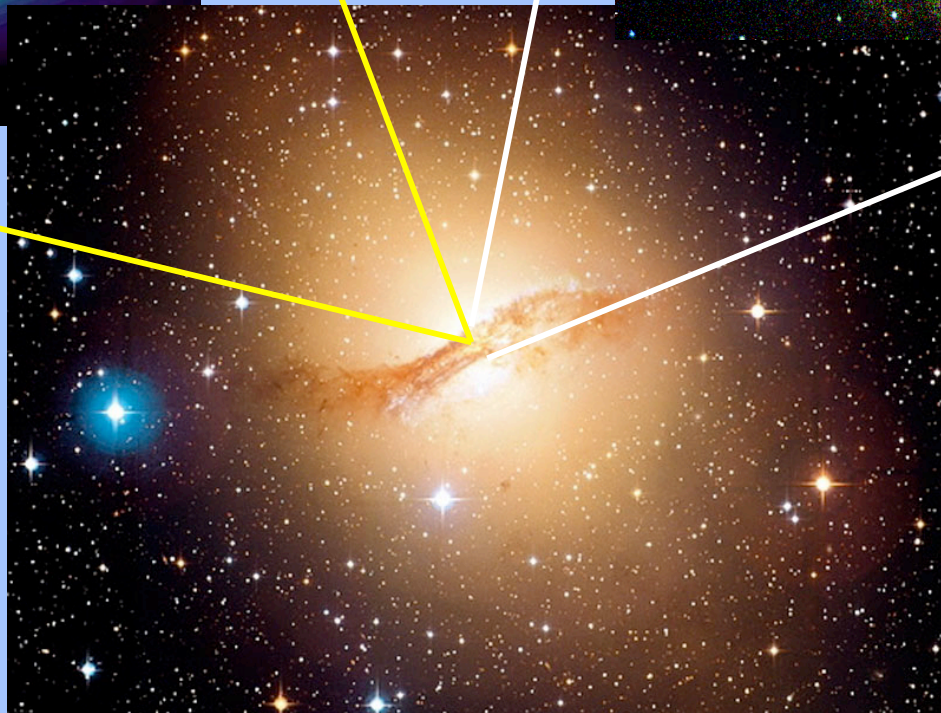
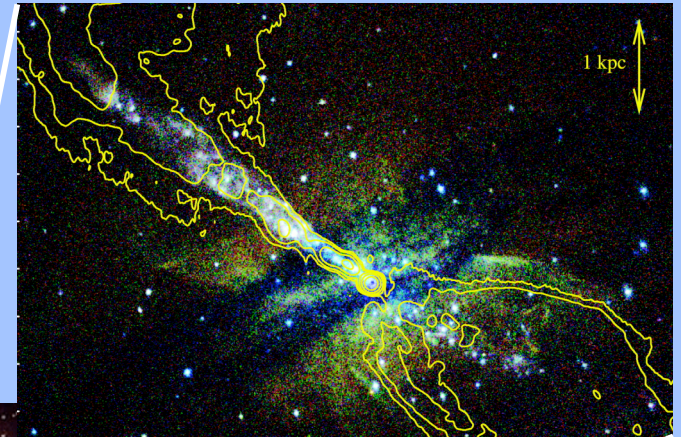
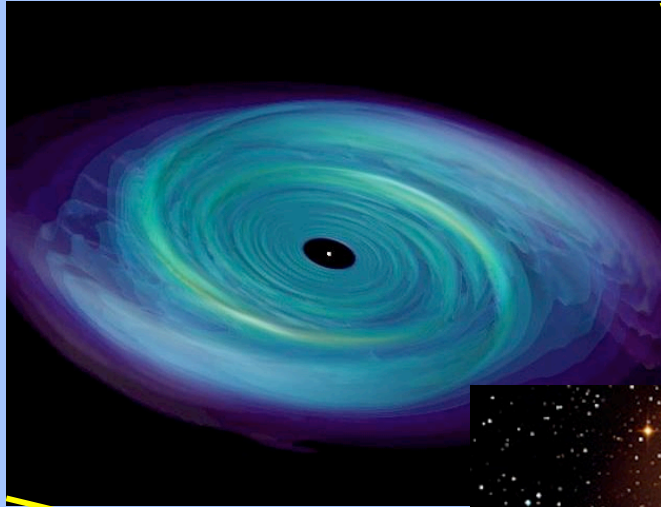


HST Ultra-Deep Field



The accelerating effect
of dark energy

Giant black holes lie at the hearts of large galaxies.



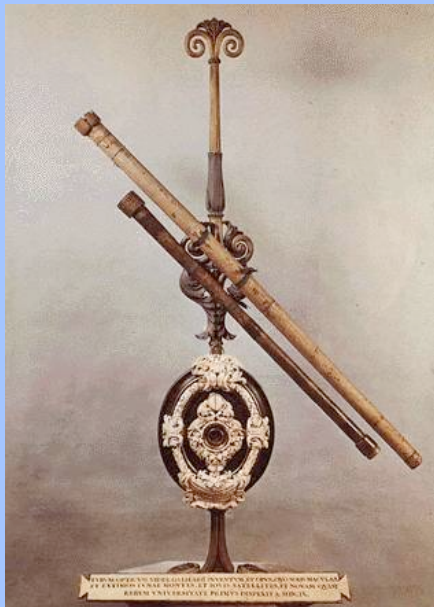
Centaurus A



Galileo (1564-1642)

First telescope observations during winter of 1609/1610, continued through 1611

Published in *Siderius Nuncius*, March 1610



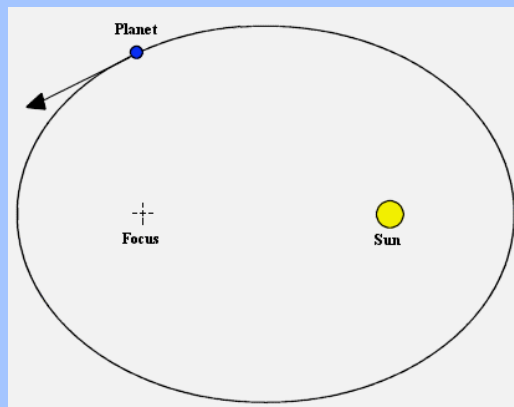


Kepler (1571-1630)

First and Second laws of planetary motion published in *Astronomia Nova*, 1609

-- Orbits are perfect ellipses; Sun at focus

$$-- \quad r^2 \frac{d\theta}{dt} = \text{const}$$



In questions of science, the authority of a thousand is not worth the sound reasoning of a single individual.

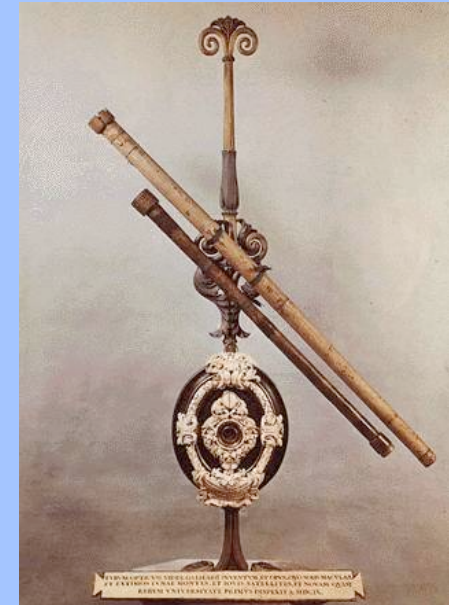
Galileo

In Philosophy, the weight of Reason alone is valid.

Kepler

Modern science began when people realized that if you are to find the truth you can't just sit around and think about it. You have to go out and see what has actually happened.

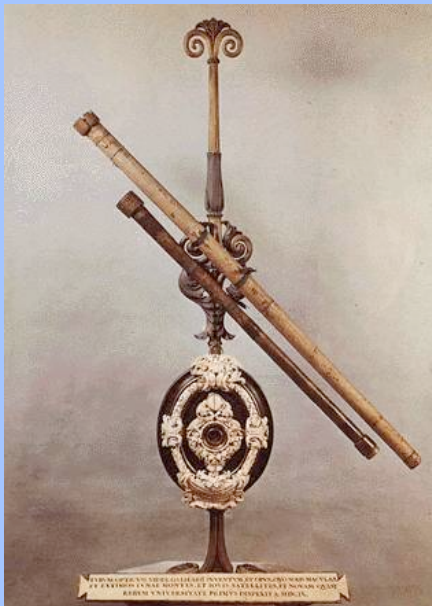
John Polkinghorne



Galileo's discoveries with the new telescope (1609-10)

1607-08 Dutch opticians developed lens technology highly enough to make telescopes adequate for astronomy. 3x "spyglasses" in common use around Europe by 1609

Galileo constructed his own 9x telescope (plano-convex objective + plano-concave eyepiece) in mid-1609



August 1609: public demonstrations in Venice to the Senate. Donated the instrument to the Doge with letter concentrating on its military advantages

Rewarded by tenure at U.Padua, though a specific provision was no subsequent salary increases

Moved to Pisa mid-1610 with considerable rise in status and fame

Discoveries in the first winter (1609-10)

With illustrations drawn from *Siderius Nuncius*

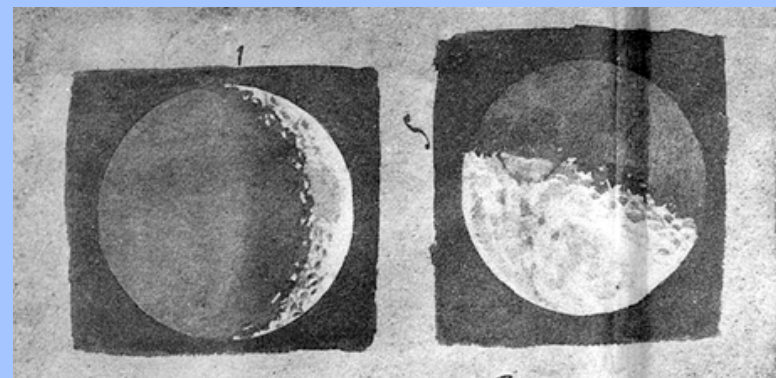
Stars “These are so numerous as almost to surpass belief”

Jupiter “There are three stars wandering around Jupiter like Venus and Mercury around the Sun”



East * ⊕ * West January 7, 1610	⊕ * * * January 8th	[CLOUDY] January 9th
* * ⊕ January 10th	* * ⊕ January 11th	* ⊕ * January 12th
* ⊕ * * January 13th	[CLOUDY] January 14th	⊕ * * * January 15th

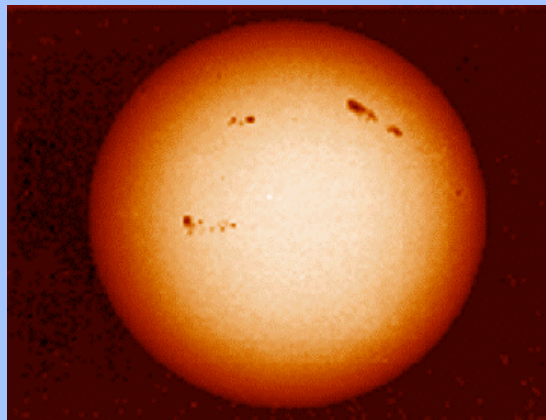
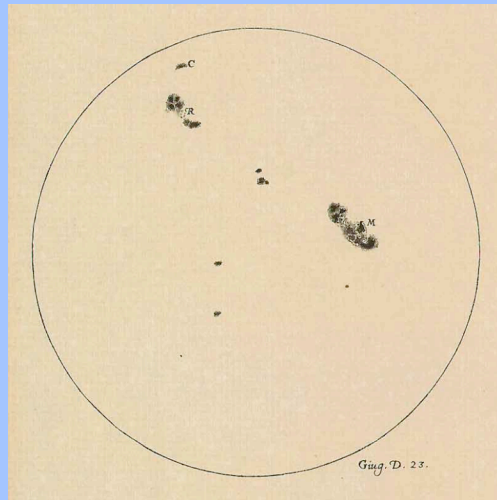
Reconstruction -- Josh Barnes



Moon “It is like the face of the Earth itself, marked with chains of mountains and depths of valleys”

"*Siderius Nuncius*" printed May 1610; led to immediate celebrity. Follow-up work in 1611-1613 showed:

Sunspots

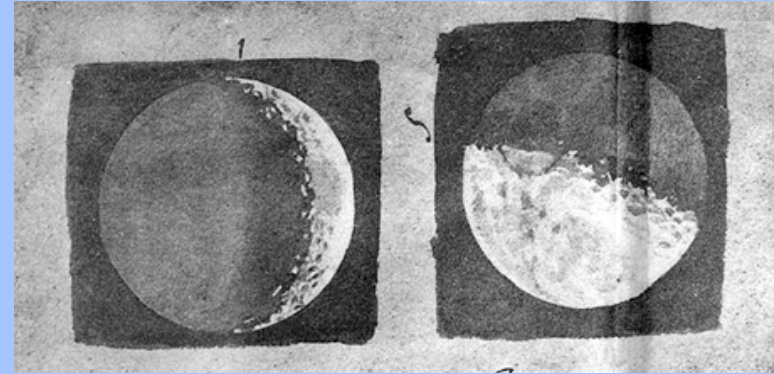
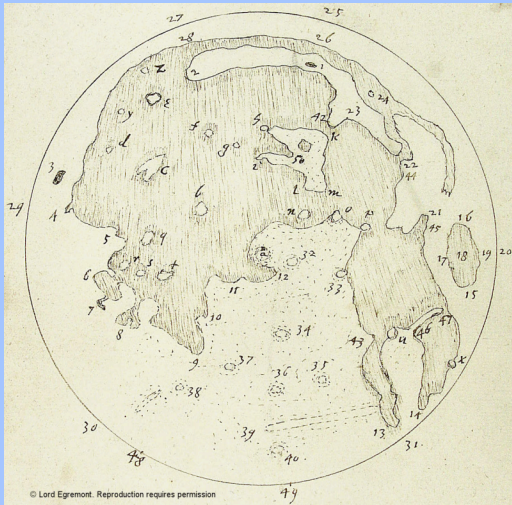


Phases of Venus



Tunc Tezel, 1997

+ proto-
discoveries of
Saturn's rings,
and Neptune

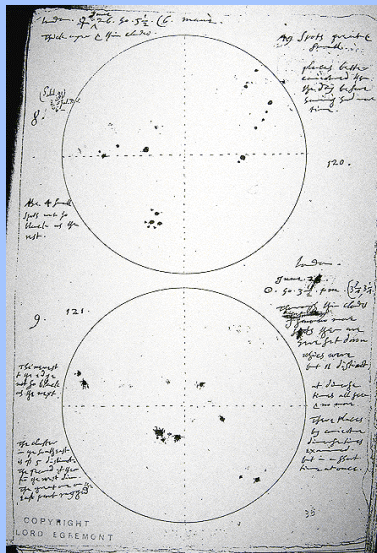


Thomas Harriott's lunar map (1611) and sunspot drawings (1610)

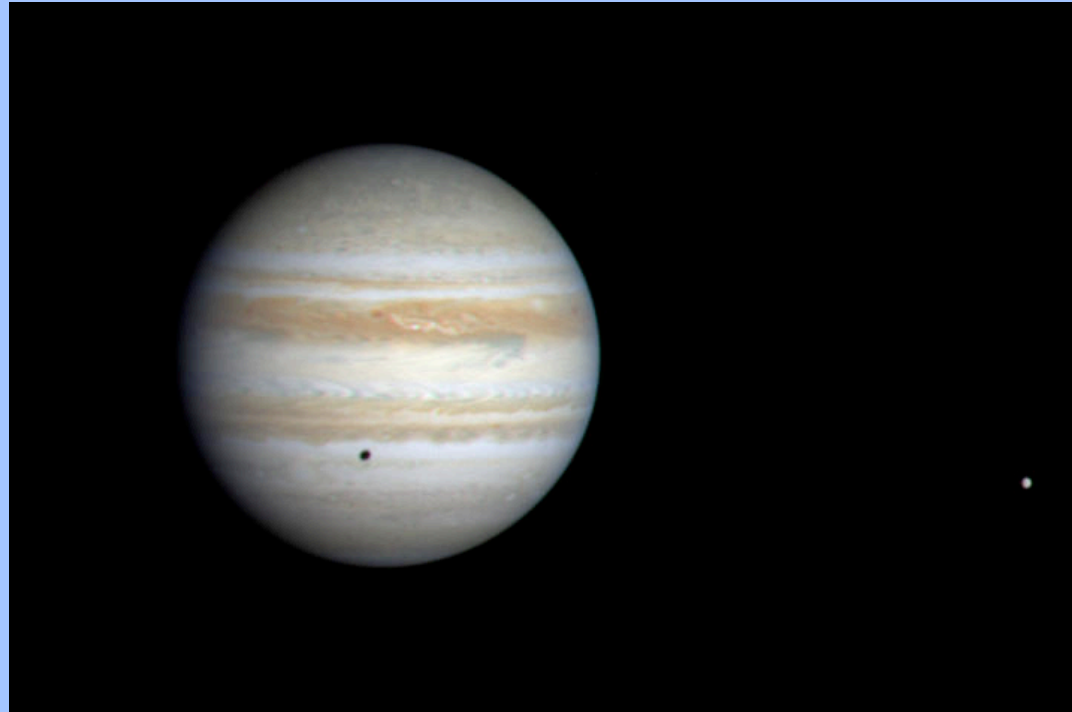
Sunspots also observed in 1611/1612 by David and Johannes Fabricius and Christof Scheiner

Simon Marius observed Jovian satellites and M31 (Andromeda nebula)

-- and others around Europe



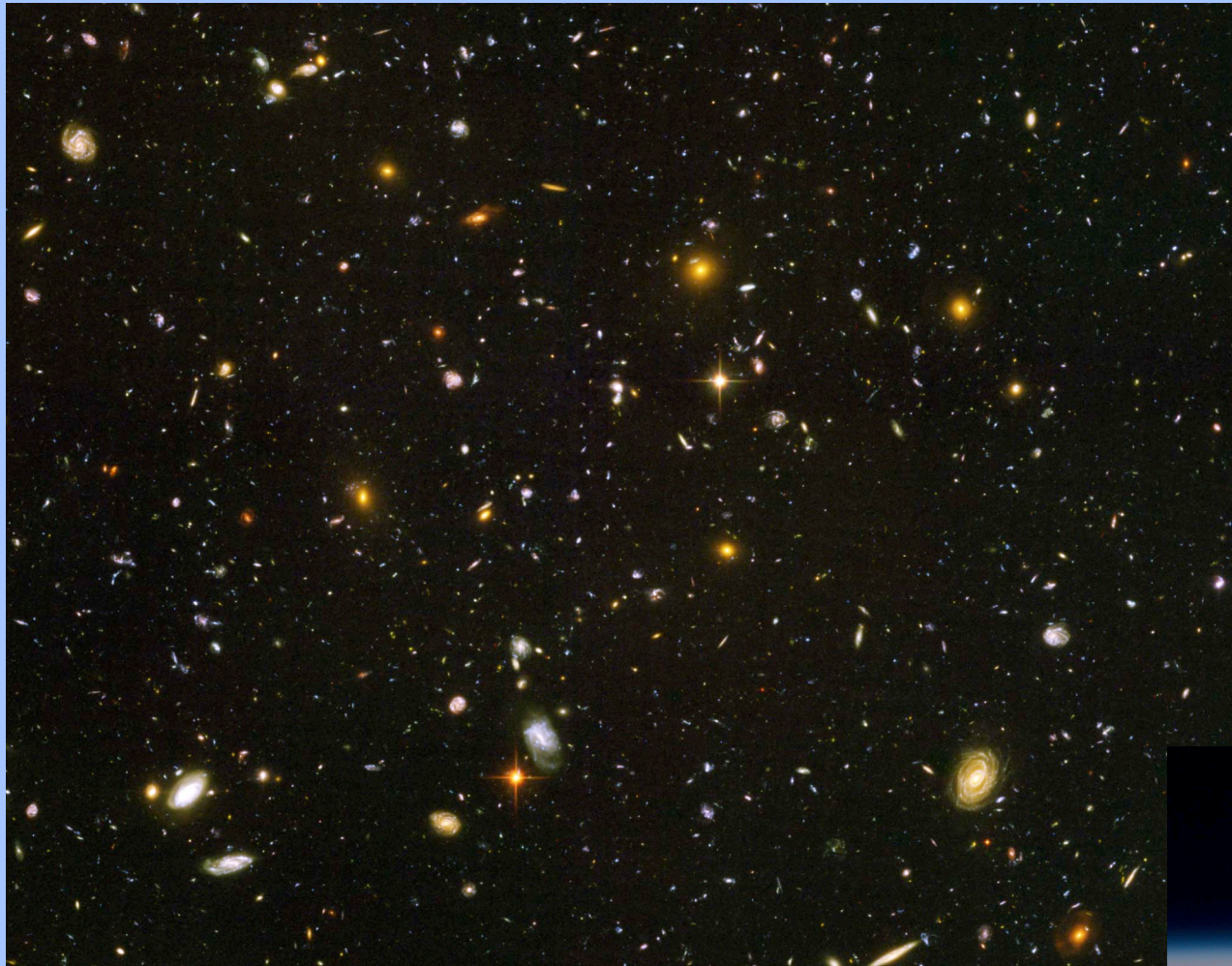
Public reactions were strong and immediately caught the “big implications”.



*How vast these Orbs must be, and how inconsiderable this Earth
... A very fit consideration for those Kings and Princes who
sacrifice the lives of so many People, only to flatter their
Ambition in being Masters of some pitiful corner of this small
Spot.*

Christiaan Huygens, ca.1690

Confronting the idea of *infinite space* -- as a real thing, not just a philosophical concept -- seems to have been the biggest item to swallow.



Hubble Telescope "Ultra-Deep Field"



*And new Philosophy calls all in doubt ...
The Sun is lost, and th'earth, and no man's wit
Can well direct him ...*

'Tis all in peeces, all cohaerence gone.

[John Donne, *Anatomy of the World*, 1611]



*When I consider the short duration of my life,
swallowed up in the eternity before and after,
engulfed in the infinite immensity of spaces
of which I am ignorant ... Who has put me
here? The eternal silence of these infinite
spaces terrifies me.*

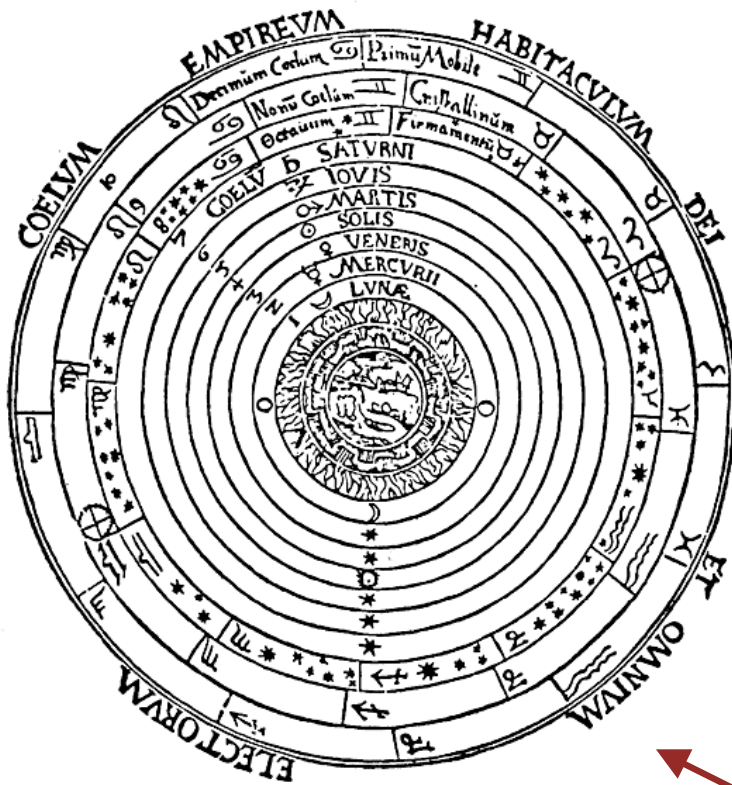
[Blaise Pascal, 1623-1662]

*We are afraid of pain
but more afraid of silence; for no nightmare
of hostile objects could be as terrible as this Void*

[W.H.Auden, *For the Time Being*, 1942]

Pascal's Syndrome: reaction to the vastness
of space and time with anxiety and fear.

Schema huius præmissæ divisionis Sphærarum.



The medieval world system
(the "Ptolemaic system" or
geocentric universe)

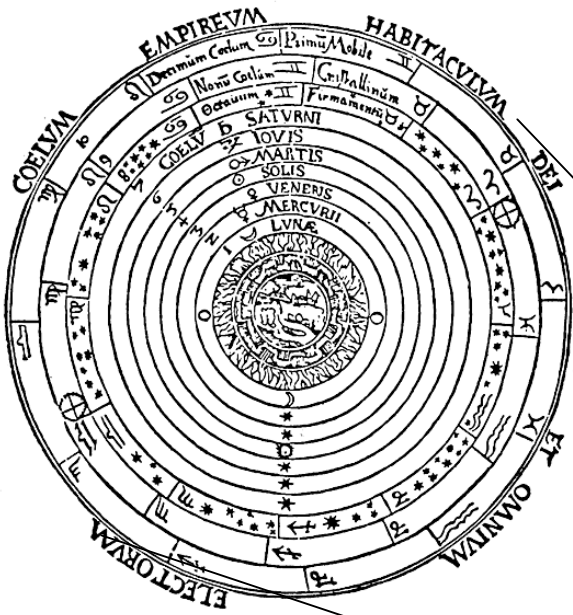
In general and official use until
Galileo's time (ca. 1600)

What's outside?

Infinite unpopulated void? (Stoic philosophy school)

No space, no time? (ongoing puzzles over "boundary problem";
variations on the "spear of Archytas" riddle)

Schema huius praeussae diuisionis Sphaerarum.

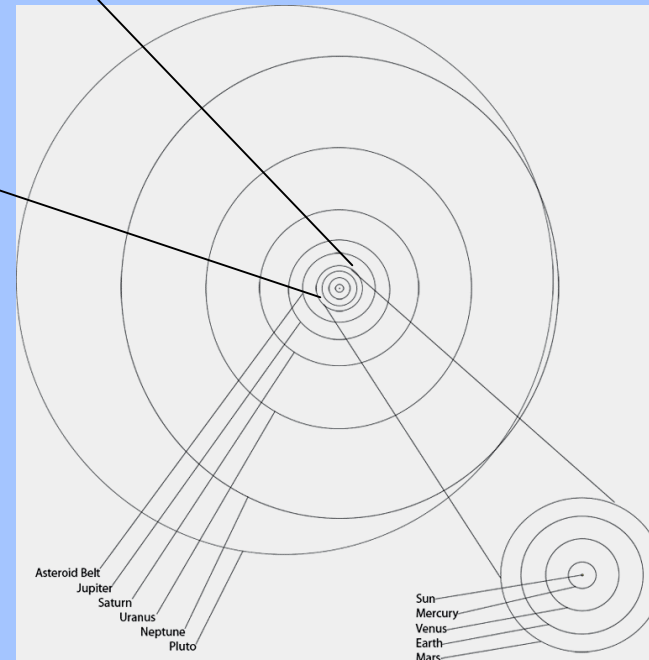


Replaced the concentric spheres (Eudoxus, Aristotle) more commonly discussed in ancient Greek philosophy

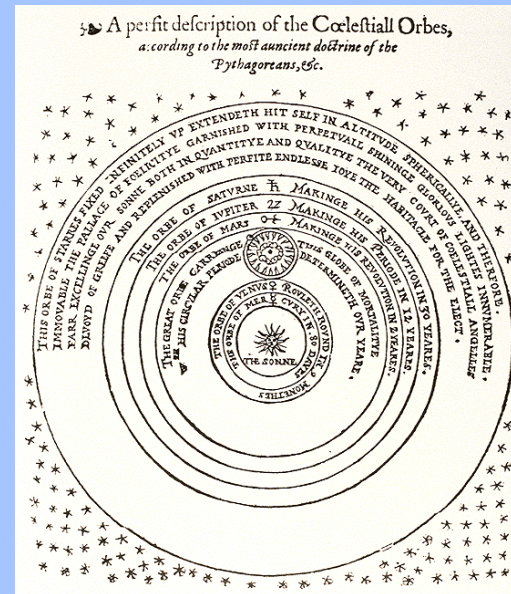
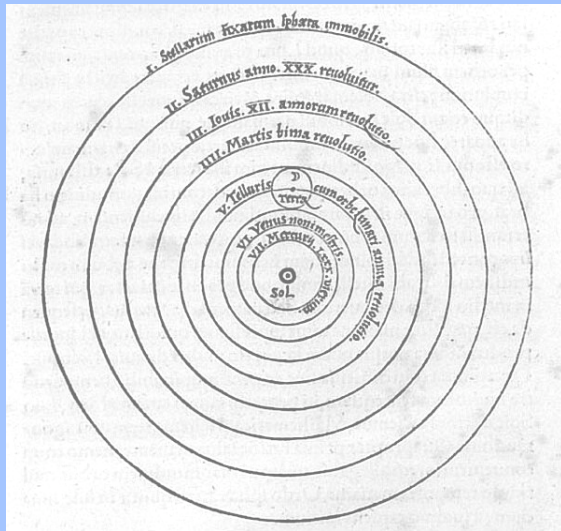
Apollonius --> shift to circular orbits + epicycles (NB -- conic sections)

Became ever more geometrically complex (epicycles, equants, deferents) in attempt to reproduce actual planetary motions

Size of Saturn's "orbit" ~ 20,000 Earth radii (about 1 AU); major calculation error was estimated distance to Sun, 20x too small



The universe according to Copernicus (1543)



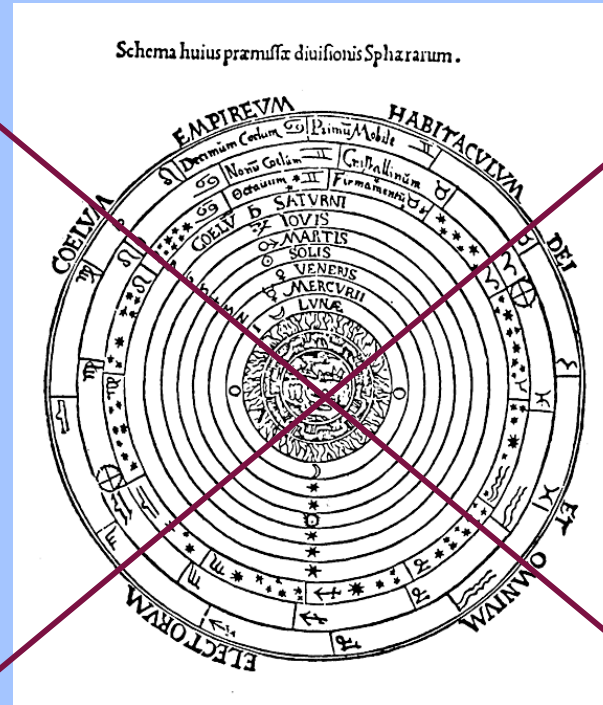
... and Aristarchus (and the Pythagoreans, to some extent)

Major conceptual advantages:

- Retrograde motion automatically emerges
- Can calculate reliable distances to planets in units of AU's
- Mercury and Venus automatically always close to Sun

Thomas Digges (1576) adds the idea of stars everywhere beyond

Galileo's findings were all directly opposed to the old Ptolemaic "model", on grounds of physical evidence rather than mathematical or philosophical argument



The end
of a
world!

In a heliocentric picture, a finite radius for the outermost "stellar" sphere is no longer required. Infinite (or vastly larger) space is permissible!

Johannes Kepler on an infinite space of stars (1605):

"This very cogitation carries with it I don't know what secret, hidden horror ... one finds oneself wandering in this immensity to which are denied limits and center"

How big was the “new” universe? Distances to the stars? Galileo and Kepler did not have the right numbers; the right picture emerged slowly over the next two centuries

1670's Cassini & Richer; Flamsteed

First direct calibration of the **Astronomical Unit** by measuring geometric parallax of Mars (though result buried in measurement uncertainties)

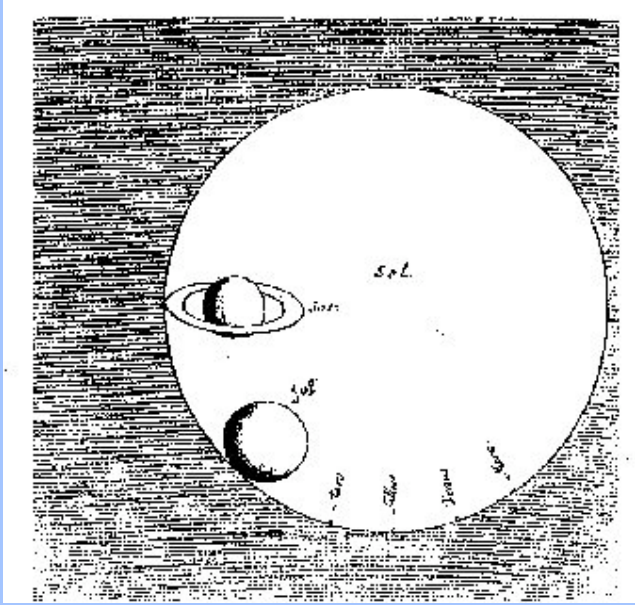
Slowly improved in late 1700's and 1800's through transits of Venus and distance to NEA Eros, incrementally converging to correct value

1698 Huygens (later Newton, using Gregory's method)

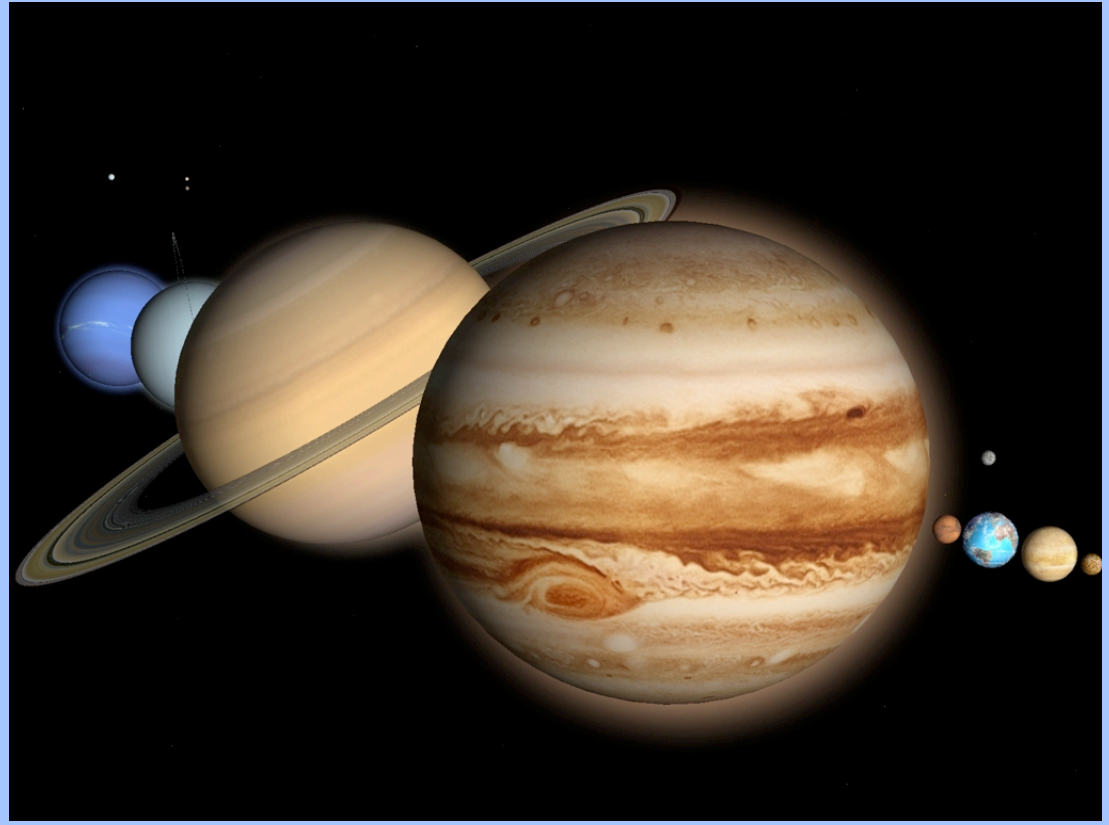
Estimated **distance to nearest stars** by brightness relative to Sun --> $d \sim 200,000$ AU or more

1838-40 Bessel, Henderson, Struve

Trigonometric parallax to 61 Cygni, α Centauri, Vega



Huygens (ca. 1700)

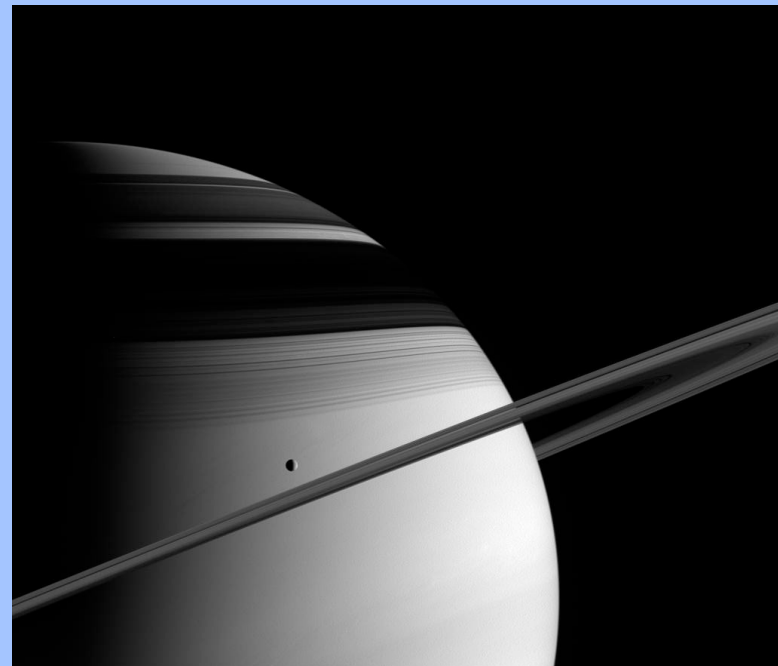


*I had a dream, which was not all a dream.
The bright sun was extinguished, and the stars
Did wander darkling in the eternal space,
Rayless, and pathless, and the icy earth
Swung blind and blackening in the moonless air ...*

Byron, "Darkness" (ca. 1816)



Galileo spacecraft image



Cassini spacecraft image

Thomas Hardy, "Two on a Tower" (1882):



There is a size at which dignity begins; further on there is a size at which grandeur begins further on, a size at which awfulness begins; further on, a size at which ghastliness begins. That size faintly approaches the size of the stellar universe.

.... Imagine [the stars] all extinguished, and your mind feeling its way through a heaven of total darkness, occasionally striking against the black invisible cinders of those stars ... If you are cheerful, leave the study of astronomy alone. Of all the sciences, it alone deserves the character of the terrible.

On the possibility of life on other worlds:

A sad spectacle. If they be inhabited, what a scope for misery and folly. If they be not inhabited, what a waste of space.

[attributed to Thomas Carlyle, 1837]



Sagittarius starfield (HST)



HST (STScI)

*There is nothing like astronomy to pull the stuff out of man,
His stupid dreams and red-rooster importance: let him count
the star-swirls.*

Robinson Jeffers (1963)



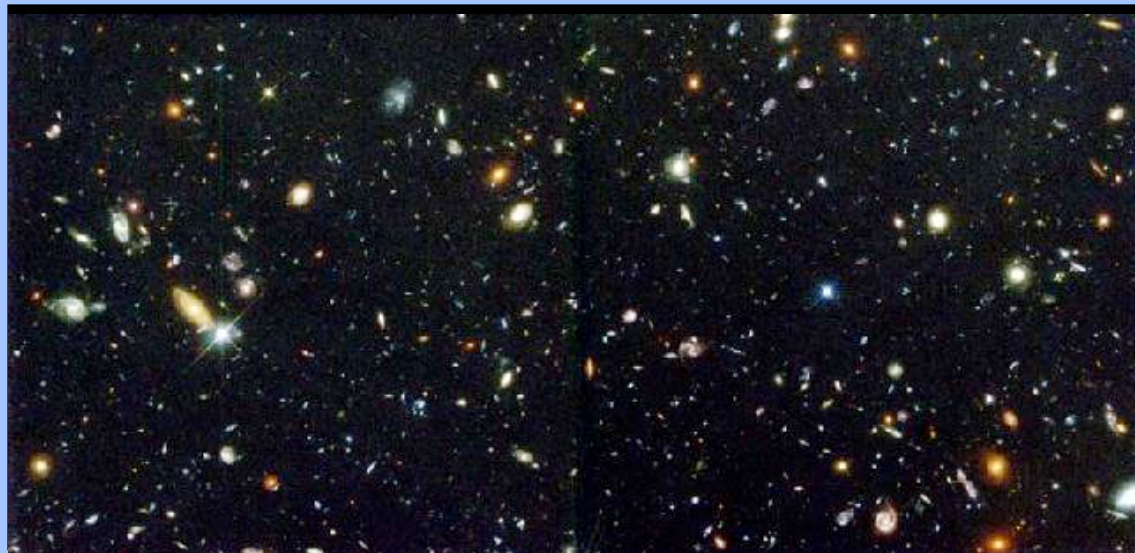
M104 (Hubble Heritage image)

*Time will come, no doubt,
When the sun too shall die; the planets will freeze,
and the air on them; frozen gases, white flakes of air
Will be the dust: which no wind ever will stir;
this very dust in dim starlight glistening
Is dead wind, the white corpse of wind.*

Robinson Jeffers
(1977)

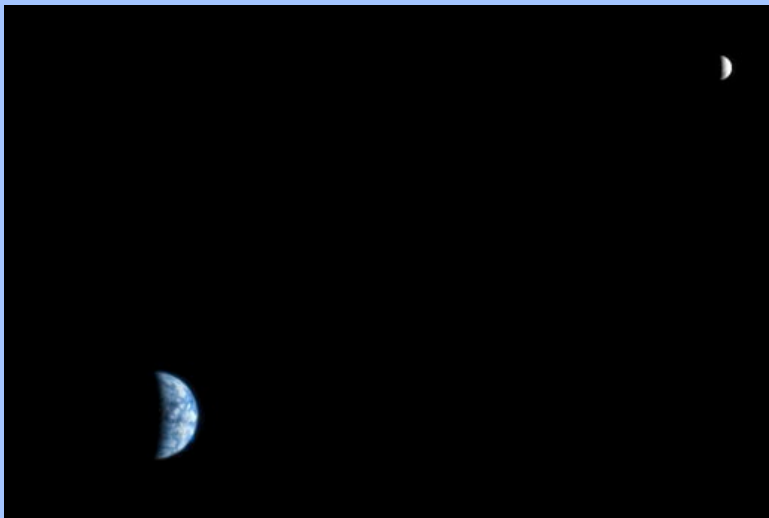
The Double Axe

*Also the galaxy will die; the glitter of the Milky Way,
our universe, all the stars that have names are dead.
Vast is the night. How you have grown, dear night,
walking your empty halls, how tall!*



... What once had been
Where heaven was, is barren beyond imagining,
And never so keenly as from out there can
The lost feel earth's the only paradise.

Jamie McKendrick (2008)



... all of us here together
Watching from our blue oasis,
Whirling in a frozen fading night
Where there is not enough
Matter to explain why any of it
Is here.

Alison Hawthorne Deming (2008)

A primitive, atavistic version of Pascal's syndrome: *cosmophobia*
(David Morrison, NASA Astrobiology Institute, courtesy of ASP)

<http://www.astrosociety.org/2012/>

The world will end in 2012 because of

Collision with Nibiru (Planet X)

End of Mayan calendar Long Count

Reversal of Earth's magnetic field

Earth crossing the "equator of the Galaxy"

(... Fill in latest mania here -- all nonsense)



*Advances in optical technology
and invention of astronomical
telescope*

*Tycho's catalog of
planetary positions*

TOOLS

Galileo

*Physical **evidence**
favoring Sun-
centered system*

Kepler

DATA

*Geometric laws of
planetary motion; new
and far superior **model***

Newtonian synthesis

"The only Remedy is a most serene and
quiet Air, such as may perhaps be found
on the tops of the highest Mountains
above the grosser Clouds."

Isaac Newton (Opticks, 1704)



CFHT

"Greatest hits" since Galileo? i.e. *publicly prominent discoveries*

Newton's law of gravity 1686

$$F = G \frac{Mm}{r^2}$$

Scientific impact:

Quantitative, enormous predictive power
Mathematical physics propelled by (e.g.)
Laplace, Lagrange, Leverrier

Halley's comet -- return predicted
1705 and appears in 1758, on
schedule

Public impact:

First *universal physical law*

Re-unification of Earth with
outside universe

Solar system much larger than
thought; its orbit carries it far
beyond Saturn. Verification of
Newtonian world system



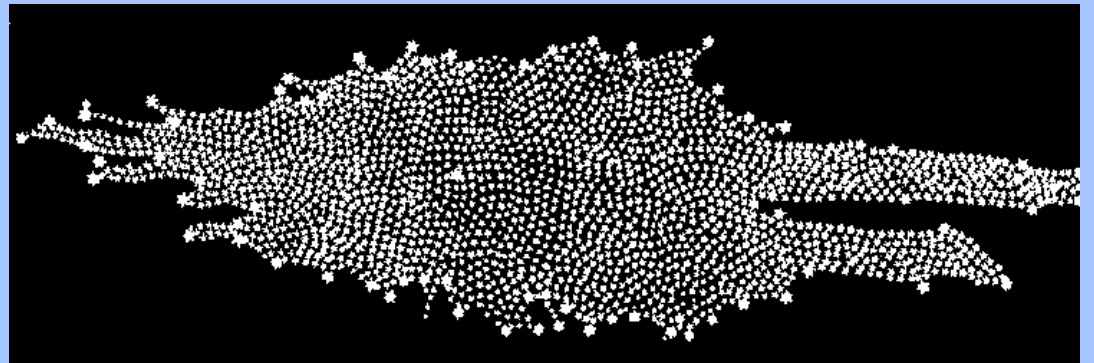
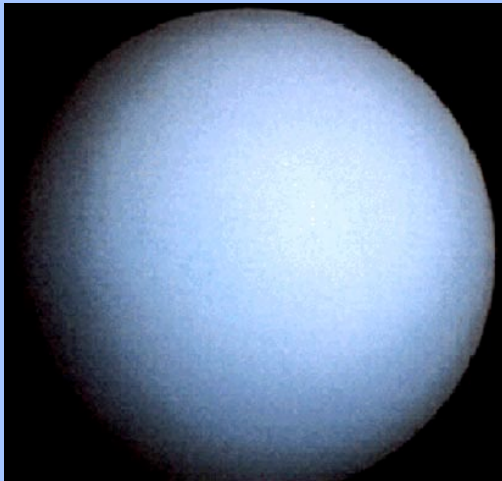
William Herschel:

Discovery of Uranus 1781

First systematic survey and outline of
the Galaxy 1780s

An unprecedented new major
planet!

Stellar universe 1000's of
lightyears big. --> The first
cosmological age problem



Successful parallax
measurements to nearby stars
(Bessel, Henderson, Struve)
1840 ++

Discovery of Neptune
Adams, Leverrier 1846

Birth of stellar spectroscopy
(Kirchhoff, Huggins; later Payne)
1860s++

First serious attempts to
determine lifetimes of stars
(Kelvin, Helmholtz) 1860s++
(coupled interestingly to geological
lifetime of Earth, and times needed
for Darwinian evolution of life)

True size of stellar universe;
confirms stars are like Sun

Another huge planet! How many
more? Newtonian mechanics the
answer to everything

The Sun and stars are made of
familiar elements! Another major
step in unification of cosmos

Element of time now enters the
picture; can the whole universe be
said to evolve?

Einstein:

Special relativity (1905)

General relativity (1915)

Pluto discovered (Tombaugh,
Lowell, Pickering) 1930

Nuclear fusion powers stars (Bethe,
Gamow, Eddington, Teller &&) 1930s

Discovery of galaxies and the
expanding universe (Hubble, Slipher)
1930 ++. Modern origin of concept
now called the Big Bang

“The universe, to use a non-scientific expression, is going hell-bent for chaos, ignoring the law of gravitation, flying ever outward, faster and faster. It looks as if the whole is breaking up and rushing into a limitless outer void.

No good can come of this.” (Springfield, Missouri Daily News, 1931)

Time and space are not what
anyone thought ...

Furor over “dwarf planets’ continues



The cosmos has a beginning; will
it have an end?

New telescopes and instruments

Palomar 200" 1950

Radio telescopes 1950++

Satellite observatories 1970++

Entirely new, detailed
views of solar system and
universe

Quasars and pulsars 1960's-70's

Extreme new states
of matter

Black holes in stars and at
centers of galaxies 1980++

Even more extreme
(ultimate?) state of matter

The CBR 1965++

The Big Bang is real; end of
steady-state universe

Dark matter (Rubin et al.) 1970++

Planets around nearby stars 1995++

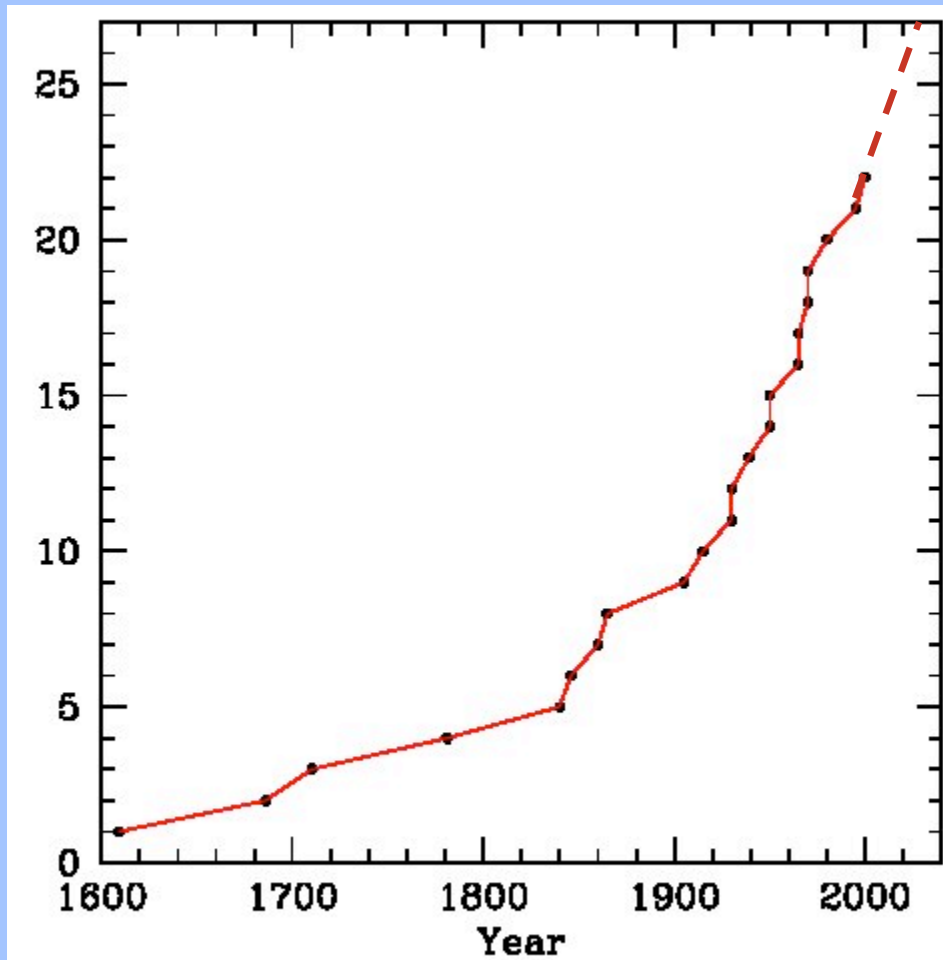
Search for life

Dark energy 2000++

Abstract and mysterious

Discovery rates: what's new?

Discovery vs. Understanding



At the same discovery rate set out in the 20th century, we should expect 4 or 5 equally big discoveries in the next 25-30 years. Will be driven by the new facilities now in construction or planning.

Astronomy in Art: escape from Pascal's syndrome

Landscape painters and other artists have usually reacted to the primary beauty of the night sky with inspiration, rather than with fear and gloom.

[Examples of the moon and stars in landscape art follow. The actual reproductions are deleted here for copyright reasons, but can all be found on the Web]

New Moon (Maxfield Parrish, 1958)

Hot Summer Moonlight (Tom Thomson, 1915)

Dovedale by Moonlight (Joseph Wright, 1784)

The Sheep Meadow (Millet, 1870)

Fishermen by Moonlight (Hendrick Avercamp, 1620)

Full Moon on the River at Brentford (Henry Pether, ca.1850)

Other, more modern examples of the moon and stars: more figurative, less literal representations

Café Terrace at Night, Arles (van Gogh)

Starry Night (van Gogh)

Starry Night Over the Rhone (van Gogh)

Moonrise (van Gogh)

Road with Cypress and Star (van Gogh)

Evening Star (Corot, 1864)

The Lawrence Tree
[Georgia O'Keeffe]

New York with Moon
[Georgia O'Keeffe]

Stars [Vassily Kandinsky]

Memphis (Tom Masse, 1999)

I know nothing with any certainty, but the sight of stars makes me dream ... why shouldn't the shining dots of the sky be as accessible as the black dots on the map of France?

Vincent van Gogh

I know that I am mortal and the creature of a day; but when I search out the massed wheeling circles of the stars, my feet no longer touch the earth, but, side by side with Zeus himself, I take my fill of ambrosia, the food of the gods.

Claudius Ptolemaeus, ca. 130 AD

The rich tradition continues.

