



THE HYPERSONIC UNIVERSE

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WHAT IS “HYPERSONIC”?

- “supersonic” refers to faster than the speed of sound
- “hypersonic” refers to speeds very much greater than the speed of sound
- “hypersonic” may casually refer to the idea of extremely fast speeds

THE SPEED OF SOUND

- The speed of sound in air is about 0.3 kilometers per second
(1000 feet per second)
- Space is NOT a vacuum. In interstellar gas the speed of sound is around a few km /sec for hydrogen
- The speed of sound depends on temperature, and there is a big range of temperatures in interstellar gas



Here a jet goes supersonic leaving behind a condensation cloud.

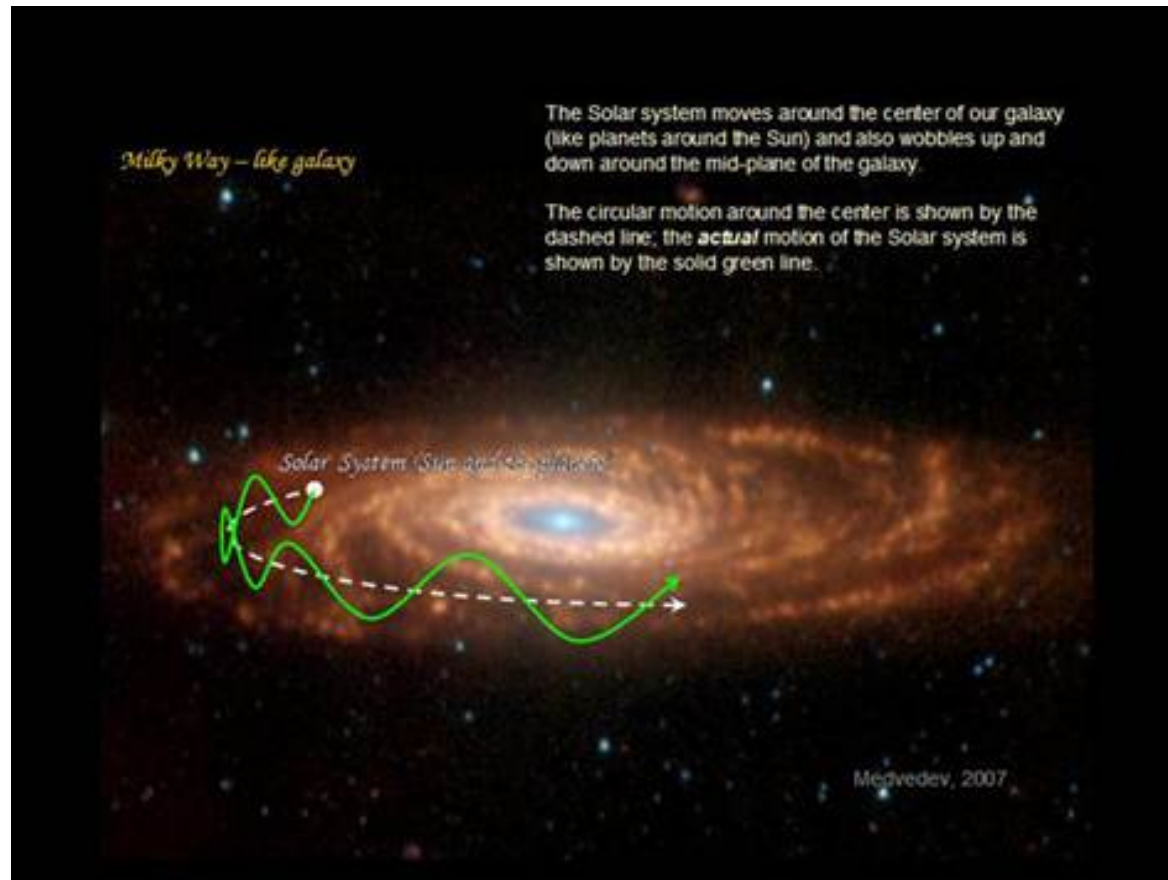
SOME FAST SPEEDS



- Voyager satellites are at large distance from the Sun, about 100 times farther than Earth.
- They are moving at more than 15 km / sec (about 35,000 mph)

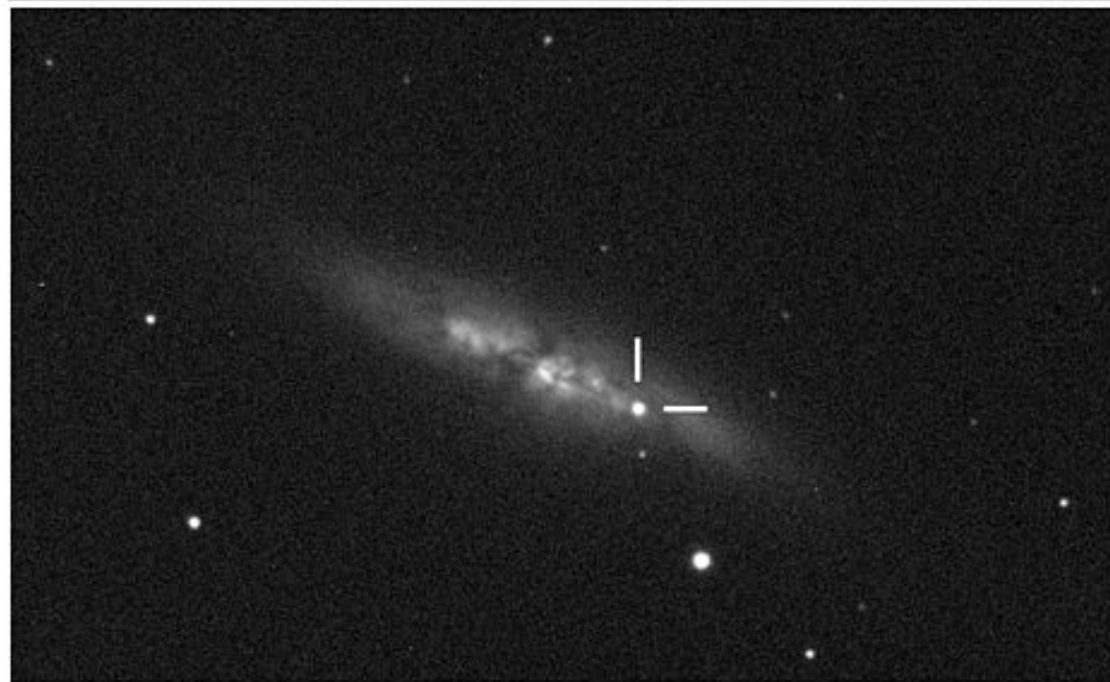
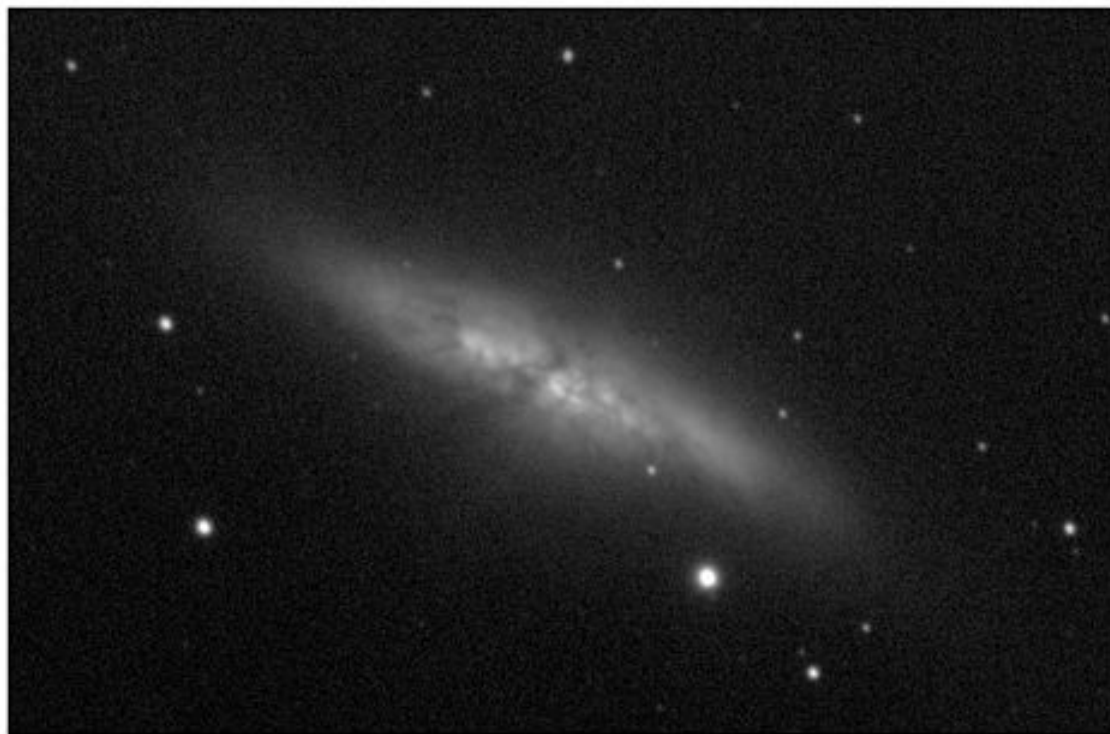
Some Fast Speeds

- The Earth orbits the Sun at 30 km / sec (67,000 mph)
- The Sun orbits the Milky Way at 250 km / sec (560,000 mph)



SOME FAST SPEEDS

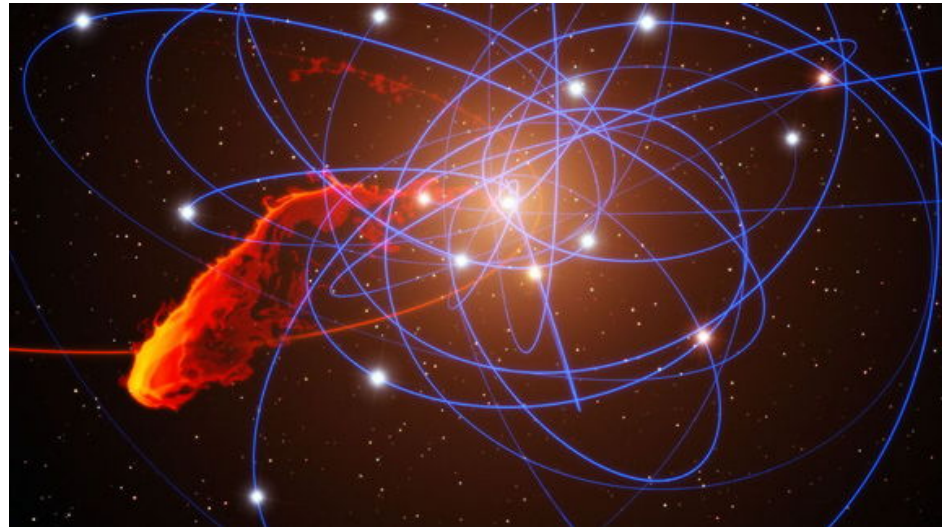
- Gases from a supernova explosion can move at around 15,000 km / sec (35,000,000 mph)
- The speed of light is 300,000 km / sec
- It takes light 8 minutes to travel from the Sun to Earth
- Right shows a new supernova in M82 (M82 is in Ursa Major)



HYPERVELOCITY STARS

- Hypervelocity stars are stars moving at great speed through space (around 1000 km/sec)
- Some of these are thought to have been “flung away” from the central massive black hole of the Milky Way
- Some are moving fast from having received a “kick” while part of a binary with a star that exploded

The bow shock of the star zeta Oph.



Orbits of stars near the Galactic Center.

WHY HYPERVELOCITY?

- Gravity dominates the universe in many respects:
 - Moons around planets
 - Planets around stars
 - Stars around galaxies
- Gravity comes with a natural “scale” for velocity called **escape speed**:
 - 2.4 km/sec for **Moon**
 - 11 km/sec for **Earth**
 - 60 km/sec for **Jupiter**
 - 617 km/sec for the **Sun**
 - Near speed-of-light for a **neutron star**





QUESTIONS?