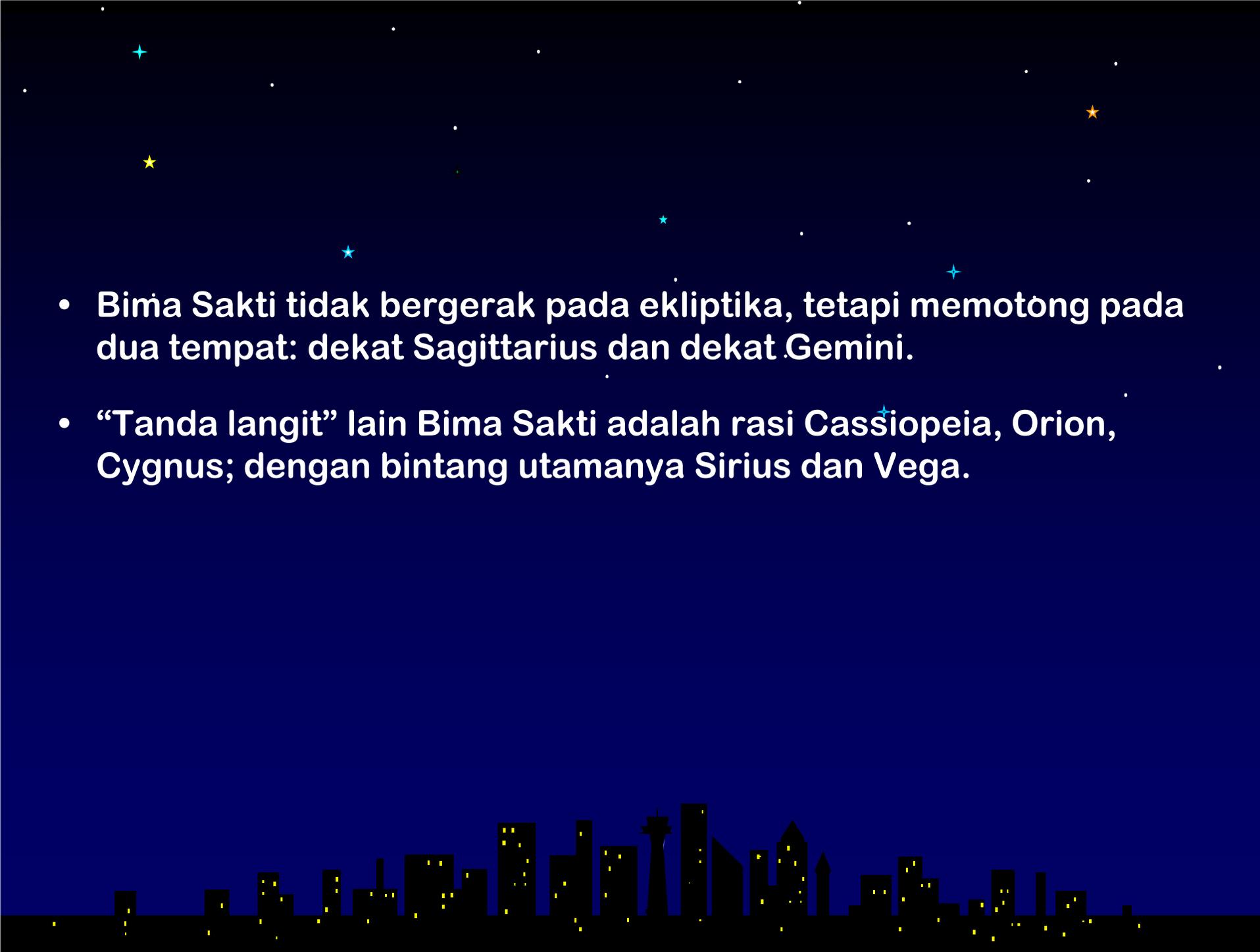


Galaksi



- Mengamati langit malam yang gelap, kita akan melihat suatu kabut tipis *seperti susu*.
- Ketika teleskop diarahkan ke daerah ini, akan tampak lebih banyak bintang suram /samar di dibanding daerah langit lainnya.
- Kabut tipis ini disebut Jalur Susu (Milky Way).
- Bima Sakti.



- 
- Bima Sakti tidak bergerak pada ekliptika, tetapi memotong pada dua tempat: dekat Sagittarius dan dekat Gemini.
  - “Tanda langit” lain Bima Sakti adalah rasi Cassiopeia, Orion, Cygnus; dengan bintang utamanya Sirius dan Vega.

# Bimasakti

- Ketika kita memandang sekeliling langit, tampak bintang-bintang di segala arah, tetapi lebih banyak bintang di sepanjang alur Bima Sakti dibanding di luarnya.
- Lingkaran Bima Sakti yang melintasi langit, menunjukkan bahwa kita (sistem matahari) ada di dalam suatu cakram tipis dengan kemiringan sekitar  $60^\circ$  terhadap ekliptika.



# Bimasakti

- We also see a lot more dust in the plane of the Milky Way.
- By looking in the infrared (which is not scattered as much as visible light by the dust and gas), we see that we are not in the center of the disk, but somewhere away from the center.
- The approximate size of the Milky Way appears to be about **100,000 light years across** and **2,000 light years thick**, and we are about **30,000 light years from the center**.
- There also appears to be a **central bulge** to the Milky Way with a radius of about **16,000 light years**.



# Gerakan Bimasakti

- Dengan mengamati bintang-bintang tetangga (ingat kita dapat menggunakan efek Doppler dan *proper motion* untuk menentukan kecepatan gerak bintang), dapat disimpulkan bahwa Bima Sakti berputar terhadap pusatnya.
- Hal inipun memperlihatkan bahwa Bima Sakti punya anggota tidak kurang dari **200 milyar** bintang.

# Gugus Bintang

- Di sekitar Bima Sakti, kita lihat “star clusters”.
- Sebagian hanya terdiri lusinan bintang, have lots of dust, and have some blue giant stars. It doesn't look like there is enough mass to keep the cluster together. These are called “open clusters” or galactic clusters.
- Others have many stars, up to about a million, have little or no dust, and have no blue giant stars. There does appear to be enough mass to keep the cluster together. These are called “closed clusters” or globular clusters.

# Star Clusters

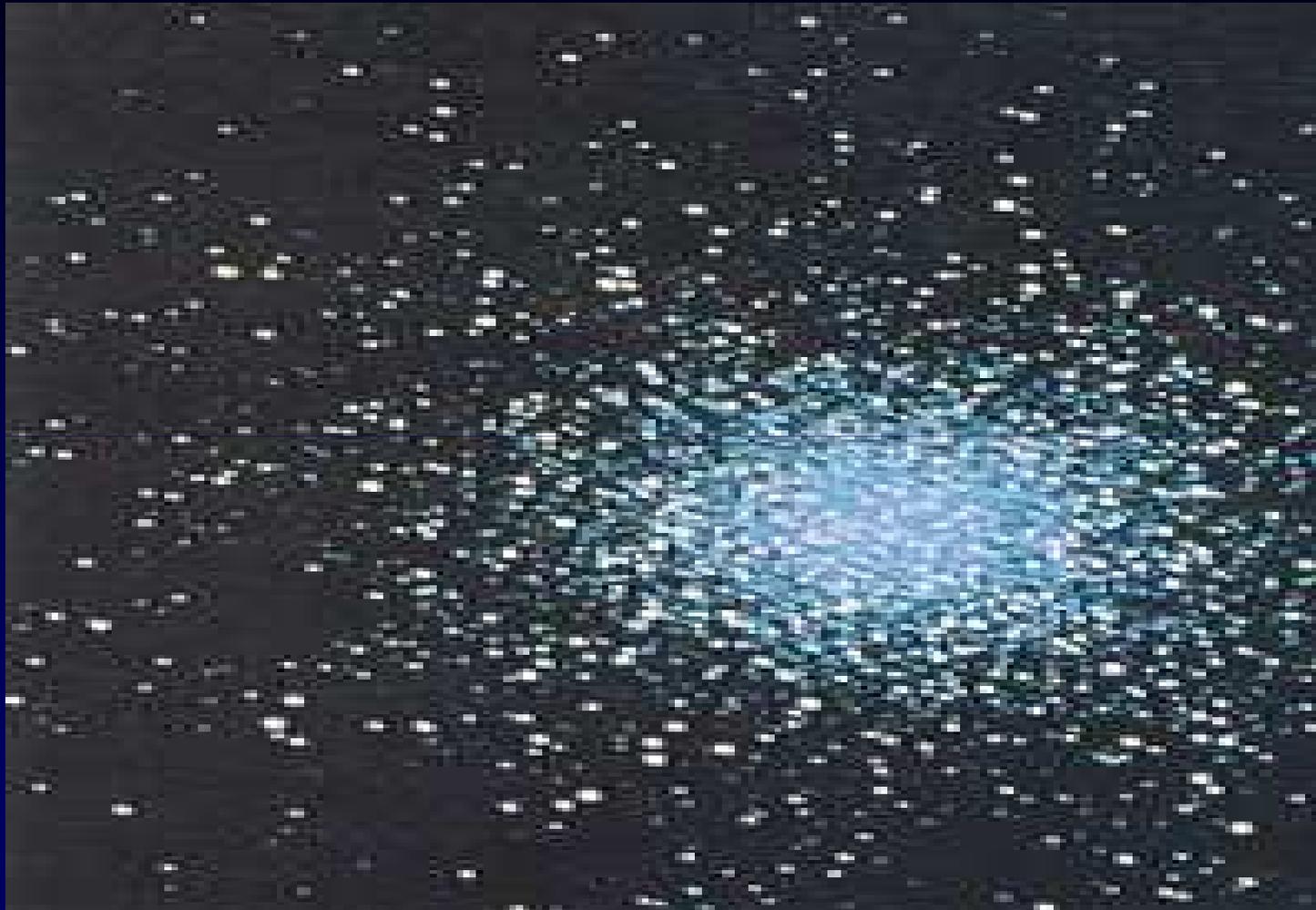
- The **open (galactic)** star clusters all seem to be in the disk of the Milky Way. They seem to be areas where star formation is happening.
- The **closed (globular)** star clusters seem to be all around the central bulge of the Milky Way. They appear, based on their H-R diagrams, to be about 10-12 billion years old.
- We can determine this age by seeing where stars are starting to leave the main sequence. (Remember, the less massive stars live longer).
- All these appear to be orbiting the center of our galaxy.



# Star Cluster



# Globular Cluster



# Large and Small Magellanic Clouds

- There are a couple of areas in the southern hemisphere that appear to be large collections of stars and are visible to the naked eye.
- These are called the Large Magellanic Cloud ( $\delta: -70^\circ$ ) and the Small Magellanic Cloud ( $\delta: -73^\circ$ ). Both have an irregular shape, have blue giants (massive, young stars) and lots of dust.
- The Large Magellanic Cloud is about **179,000 light years away**.
- The Small Magellanic Cloud is about **210,000 light years away**. Both Clouds appear to be gravitationally bound to the Milky Way.



# Galaksi

In looking through telescopes, especially the more powerful ones, we can see huge collections of stars. They appear to be of three major types:

1. **Elliptical** Galaxies. There are both big and small varieties.
2. **Spiral** Galaxies. There appear to be only big varieties.
3. **Irregular** Galaxies. These appear to be only small.



# Elliptical Galaxies

- **Giant** elliptical galaxies are rare, but can contain the mass of a trillion stars and be 2 million light years in diameter.
- **Dwarf** elliptical galaxies are very common, and contain the mass of only a few million stars.
- Elliptical galaxies are also classified by their **roundness** as viewed from the earth. E-0's are the roundest, and E-7's are the most elongated.
- Elliptical galaxies, like the closed (globular) clusters, seem to contain little gas and no blue giant stars (young stars).



# Spiral Galaxies

- Spiral galaxies are all giants. They have dust and blue giant (young) stars in the arms. They are of two major types: **barred** and **regular**. The Barred type have bars instead of central bulges. Each has three major sub-types:
- **Spiral A:** Largest with largest central bulge and most tightly wound arms.
- **Spiral B:** Inbetween case – Milky Way and Andromeda are examples.
- **Spiral C:** Smallest (but still giant) with smallest central bulge and loosely wound arms.

# Irregular Galaxies

These galaxies show no regular symmetry. They are usually small compared to the giant types. They have lots of dust and have blue giant (young) stars.



# Galactic Evolution

- Do galaxies “evolve” from one type into another?
- Based on the different masses of the different galaxies, it appears that they **do NOT evolve** from one type into another.
- Some of the galaxies appear to “collide” with other galaxies as they move, and such a collision may affect the shape. Some of the bigger galaxies may actually “eat” or absorb smaller nearby galaxies.

# Clusters of Galaxies

- Do galaxies cluster together like stars do?
- When we look around, we do indeed see that galaxies appear in clusters, and appear to orbit one another by their mutual gravity.
- The Milky Way is one of about 40 or so galaxies that form the **Local Group**. Andromeda (another spiral-B galaxy about 2 million light years away) and the Milky Way are the biggest members. There is a third spiral-C (Triangulum, about 3 million light years away) along with the Magellanic Clouds and quite a few dwarf ellipticals. All of these orbit around the (gravitational) center of the system.

# Clusters of Galaxies

We have found two general types of clusters of galaxies:

- **Regular clusters** have a spherical distribution of galaxies with up to 10,000 galaxies.
- **Irregular clusters** have fewer galaxies that are more randomly spread out over space. (The Local Group is such an irregular cluster.)



# Clusters of clusters?

- Stars are grouped together (by gravity) into galaxies.
- Galaxies are grouped together (by gravity) into clusters.
- Are clusters of galaxies grouped together by gravity?



# Superclusters

- Yes, clusters of galaxies that are grouped together by gravity are called **superclusters**. Superclusters usually contain dozens of clusters and are spread over a volume of space with a **diameter of about 150 million light years**.
- Our local group is a member of the supercluster of galaxies centered on the rich regular cluster in Virgo about 60 million light years away. It appears the local group is on the edge of this supercluster.

# ★ Clusters of Superclusters?

- Are there clusters of superclusters, or where, if anywhere, does the clustering end?
- It appears that there is some kind of structure to the superclusters.
- The superclusters surround roughly spherical volumes of space that have very few galaxies and measure 100 million to 400 million light years in diameter.



# Motions of the galaxies

- By using the doppler effect on spectra, we can determine the motion of light emitting objects towards (blue shift) or away (red shift) from us.
- It is only possible to determine the sideways motion of objects if they are close enough and move fast enough to make a measurable angular change in their location. This can happen for the nearer stars, but not for anything further away.



# ★ Red Shift of the galaxies

- What we observe when we look at spectra from the galaxies is that the further away the galaxy is from us, the bigger the red shift of the spectra from that galaxy.
- This is called **Hubble's Law**.



# Review: How We Determine Distance

1. Parallax works for the nearest stars.
2. Identify stellar types (such as blue giant stars and red giant stars), determine luminosity from the type, measure brightness, and then calculate distance. If the giant star is in a cluster, then we can determine the distance to the cluster by using several giant stars in the cluster to get its distance.
3. Cepheid Variables: By measuring the period of a cepheid variable, we can use the period-luminosity relationship to get the luminosity. Then by measuring the brightness, we can determine the distance. This works for the nearer galaxies.
4. Spiral galaxies appear to be uniform in size and luminosity based on their classification. By knowing their luminosity from their type, and measuring their brightness, we can calculate their distance.
5. By using the red-shift of spectra from distant galaxies, we can then use the Hubble Law to calculate their distance.

# Quasars

- **Quasars**, also known as Quasi-stellar radio sources and as quasi-stellar objects or QSO's, look like stars but **have extremely high red shifts**.
- If the quasars' distances really are what Hubble's Law would indicate, they must be on average about **100 times more luminous than the Milky Way Galaxy**, but their light comes from a source that can be about the size of our solar system!
- The highest red shifted quasars would be about **10-12 billion light years away** if Hubble's Law applies to them.



**Tks...!**

