Telescopes 101

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What we're going to talk about tonight….

- Things to consider when looking at a telescope
- Focal length, aperture, and f/ratio
- Telescope mounts
  - Equatorial
  - Alt-az
  - Dobsonian
- Three major telescope designs (pros/cons)
  - Refractor
  - Reflector
    - Dobsonian
  - Schmidt-Cassegrain (SCT)
- Questions from audience

First...

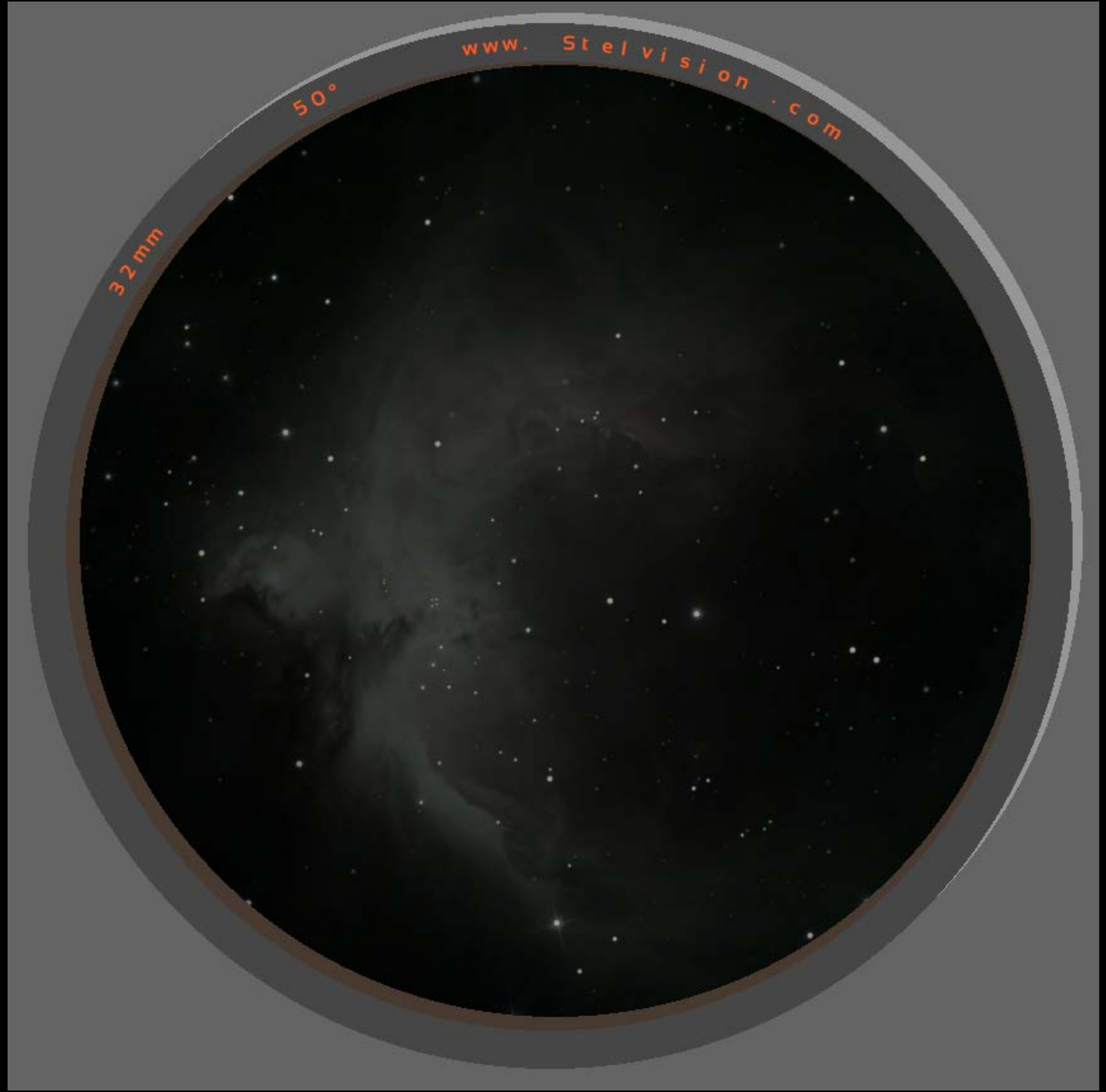
- What telescope should I buy?
- 6” or 8" Dobsonian telescope
- Costs around $400
- Large but very stable
- Available from...
  - Orion
    - XT6, XT8
  - Apertura
    - AD8
  - Skywatcher
    - 6" Traditional Dobsonian
    - 8" Collapsible
  - Zhumell
    - Z8 Deluxe Dobsonian Reflector Telescope
- Available wherever you have an internet connection

Second…

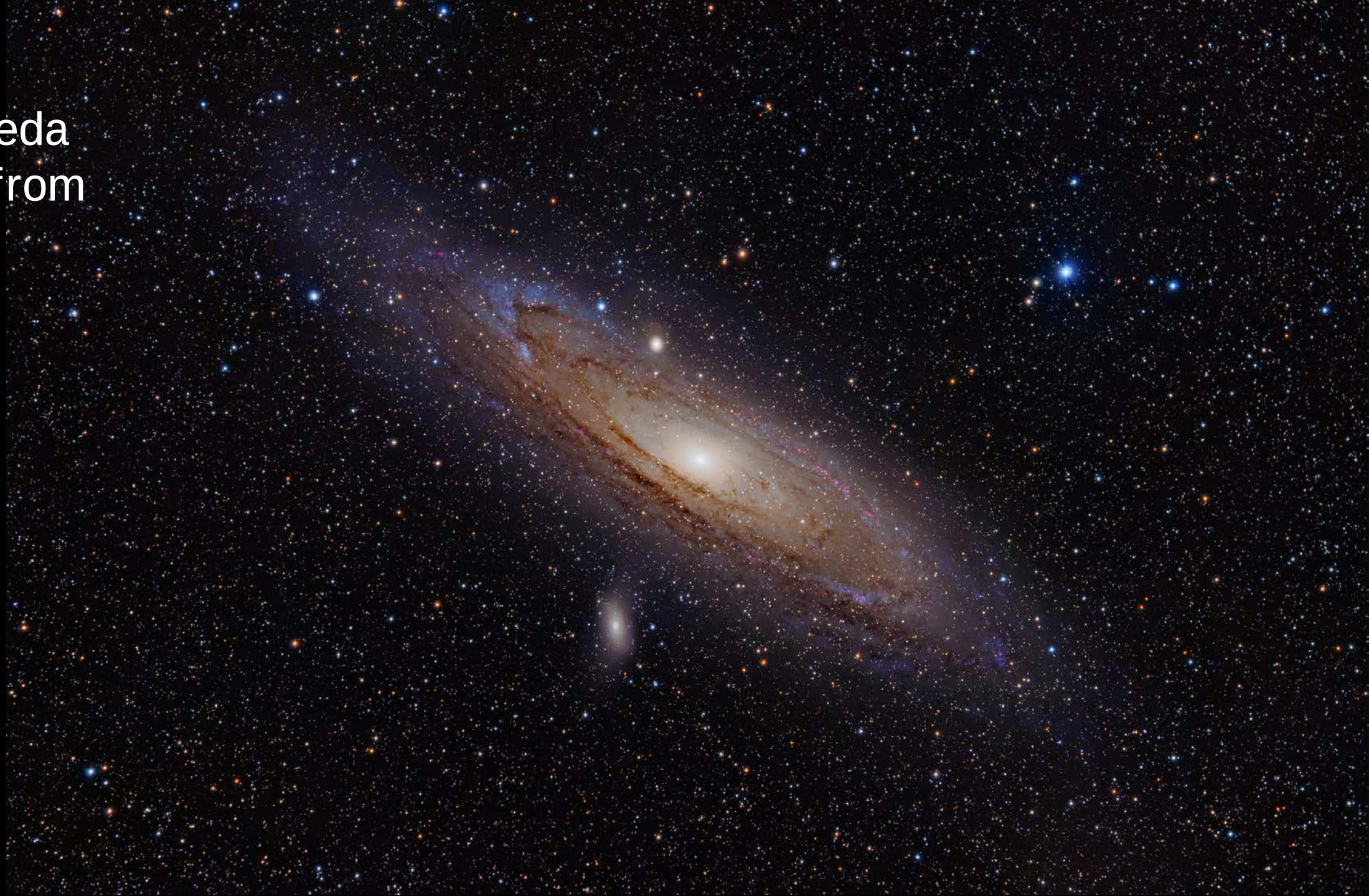
- What will I see through a telescope?

M42 (Orion Nebula) from Hubble

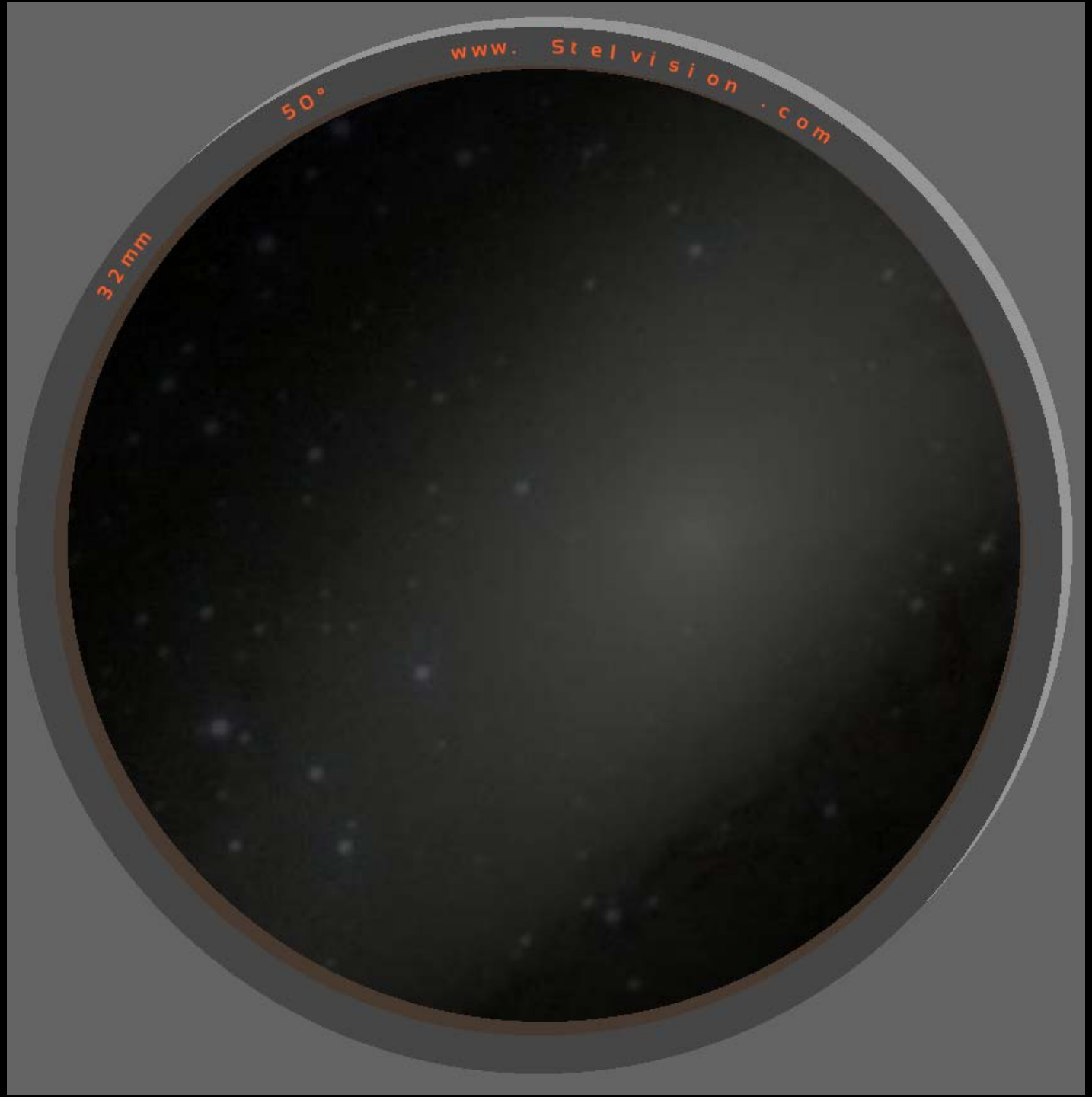
M42 (Orion Nebula) from 8” telescope with 32mm eyepiece

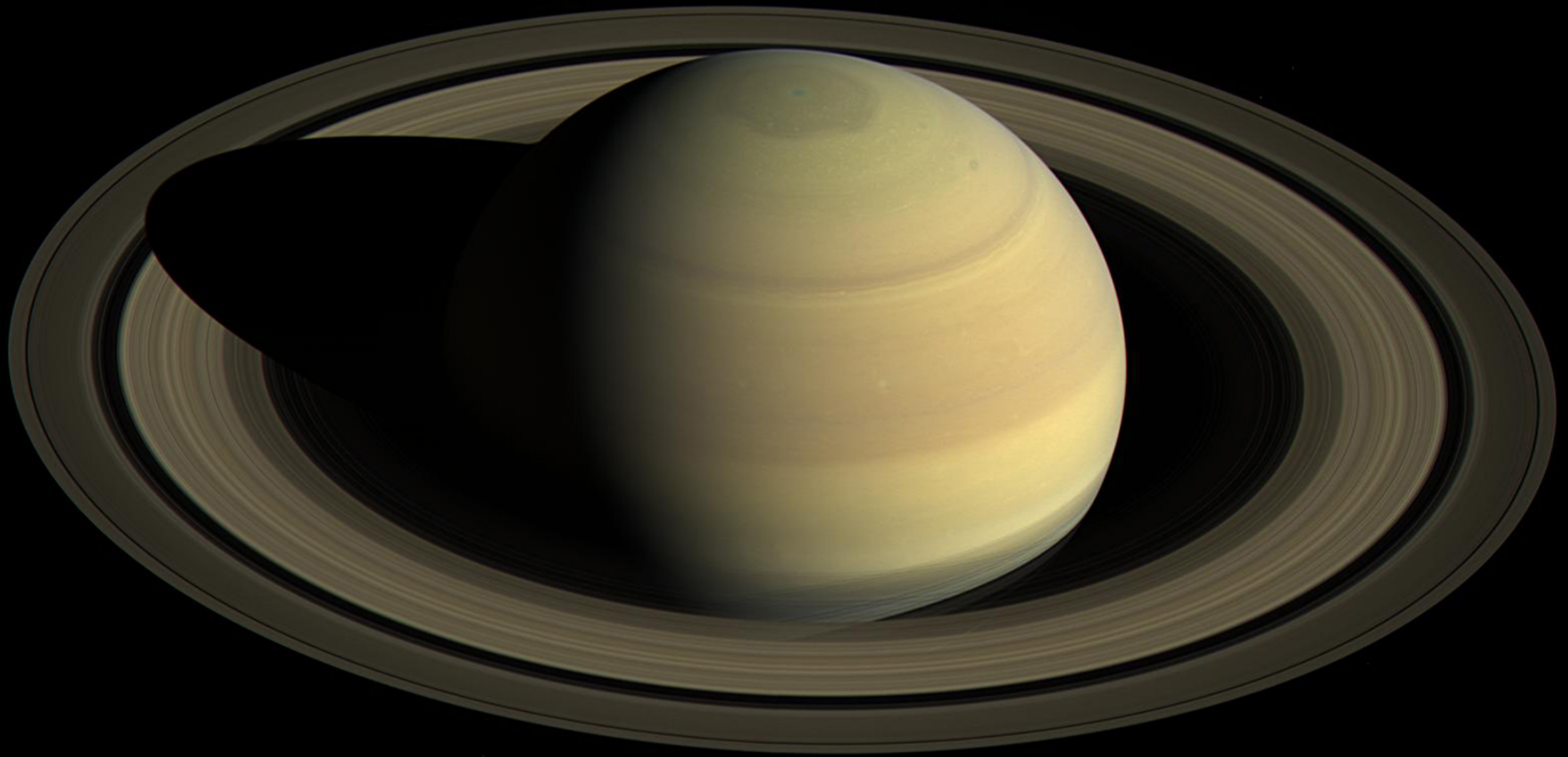


M31 (Andromeda Galaxy) from Hubble



M31 (Andromeda Galaxy) from 8” telescope with 32mm eyepiece





Saturn from Cassini

Saturn from 8” telescope with 12mm eyepiece

If you want this

Spend your money on that

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Now that I’ve crushed your dreams

We’re going to talk about….

- Things to consider when looking at a telescope

Things to consider when looking at a telescope

- What's the aperture?
  - How much detail am I going to see?
  - Is it going to show me what I want to see?
- How much does it weigh / how physically big is it?
  - Can I move it around? Do I have a place to store it?
- How much does it cost?
- Is the mount stable and easy to use?
  - How much time do I want to spend setting it up?
- Who is going to be using it?
  - Adults, kids, public, etc.

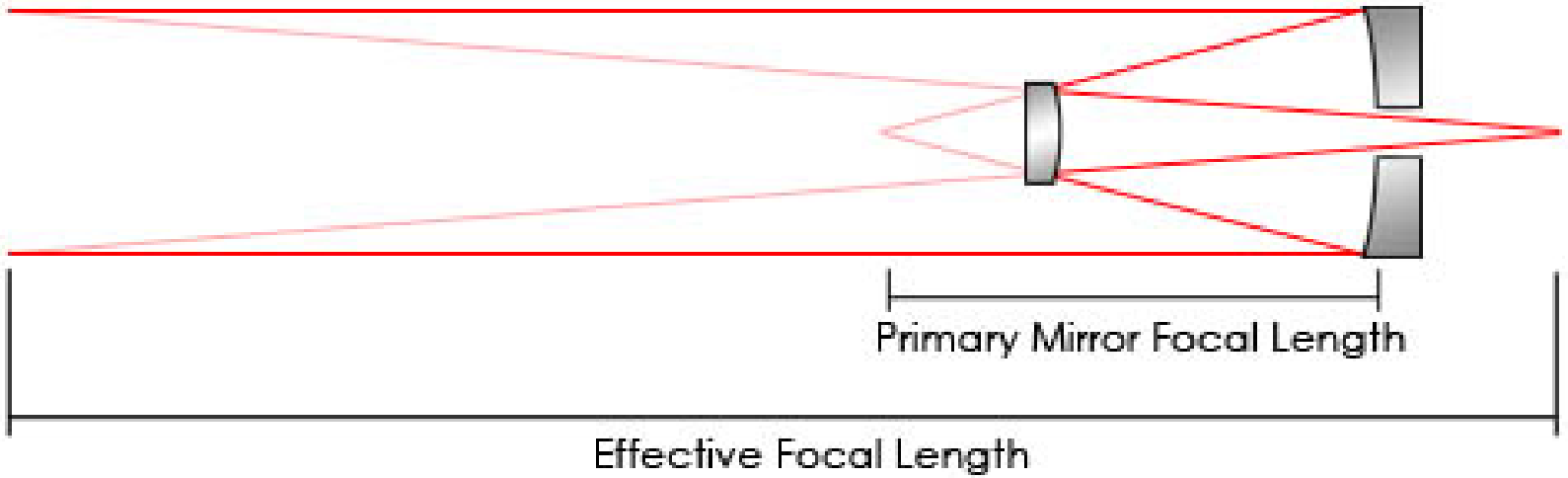
Questions

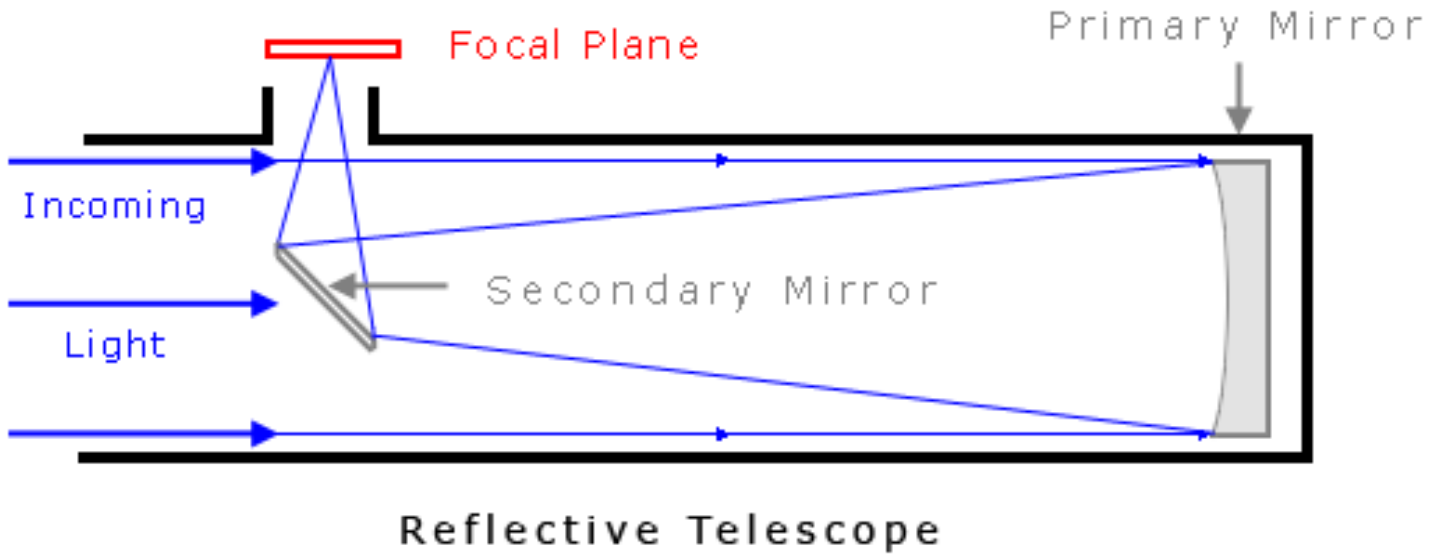
We’re going to talk about….

- Focal length, aperture, and f/ratio

Focal Length

- Focal length is how far the light has to travel in the tube of the telescope
- For example, 2032mm, 910mm, 100mm, 8”, 11”
- Focal length determines magnification!





Focal Length and Magnification

- Focal length determines magnification!
- Magnification = focal length of the telescope divided by focal length of an eyepiece
- For example…
  - If you have a telescope that has a 1000mm focal length and you are using a 20mm eyepiece, you will be getting 50X (1000mm/20mm = 50X)
  - If you have a telescope that has a 500mm focal length and you are using a 20mm eyepiece, you will be getting 50X (500mm/20mm = 25X)
- Life is not CSI…
  - More magnification means a dimmer view (same amount of light is spread out over a larger area), many objects are best viewed at LOW magnifications, e.g. galaxies
  - High magnification means nothing if the telescope doesn't collect enough light!

Questions

Aperture

- A telescope's main purpose is to collect light. This property of telescopes allows you to observe objects much fainter than you can see with your eyes alone.
- Aperture: the diameter of the main, light-gathering lens or mirror
  - Good telescopes are referred to by their aperture, e.g. 60mm, 80mm, 8", 9.5"
- The bigger the aperture, the sharper and brighter the view will be.
- Larger aperture shows fainter objects, shows more detail in objects, and increases the "life" of a telescope (can use bigger, longer focal length eyepieces, see more, etc.)
- When in doubt, go bigger

Questions

f/ratio

- f/ratio is the focal length of the telescope divided by its aperture
  - Focal length is how far the light has to travel in the tube of the telescope
  - Aperture: the diameter of the main lens or mirror
- For example:
  - A telescope with a focal length of 910mm and aperture of 60mm will have a f/ratio of 910/60 = 15 (f/15)
  - A telescope with a focal length of 2032mm and aperture of 203.2mm will have a f/ratio of 2032/203.2 = 10 (f/10)

f/ratio

- "Fast" f/ratio (f/3 – f/5) give lower power, wider fields of view and usually brighter images
  - Good for wide field views of galaxies, open star clusters, nebulas
  - Generally: fast focal ratios = smaller focal lengths = shorter tubes

- "Slow" f/ratio (f/6 and above) give higher power, smaller fields of view, and slightly dimmer images
  - Good for "small" objects like the planets, double/binary stars, small globular clusters
  - Generally: slow focal ratios = larger focal lengths = longer tubes
    - Exception with SCTs

Focal length, aperture, f/ratio

- Long focal length can mean high magnification, but also a long, heavy tube and small aperture (less light, limited viewing)
- Short focal length can mean low magnification, but also a shorter, lighter tube and larger aperture (more light, more viewing)
- f/ratio gives a quick way to compare those focal length and aperture, and somewhere around a f/5 or f/6 is usually good for amateurs
  - Large enough to see things, small enough to move around

Questions

We’re going to talk about….

- Telescope mounts
  - Equatorial
  - Alt-az
  - Dobsonian

Telescopes Mounts

Equatorial (EQ)

- Aligned with Earth's axis
  - Points at north celestial pole (Polaris)
- Once an object is located, telescope only moves on one axis
- Can be more complicated to set up
- At high magnifications, errors in finding/tracking will be more obvious
- Cheap EQ mounts won't track or move well
- Can't easily observe objects near Polaris
- Large EQ mounts can get very heavy
- Good for astrophotography

Telescopes Mounts

Alt-az

- Moves up-down (altitude)
- Moves left-right (azimuth)
- Once an object is located, telescope moves in two axes so object will rotate as night goes along (“field rotation”)
- Easy set up
- Can be more finicky to track objects if you forgot which knob to turn or button to press
- Cheap gears won’t move or track well
- Can’t easily (or at all) observe object overhead

Telescopes Mounts

Dobsonian

- Type of alt-az mount (up-down, left-right)
- Uses “rockerbox” style base
- Allows observing objects directly overhead
- Easy set up
- Most popular style for amateurs
  - Generally uses a Newtonian reflector telescope

Telescopes Mounts

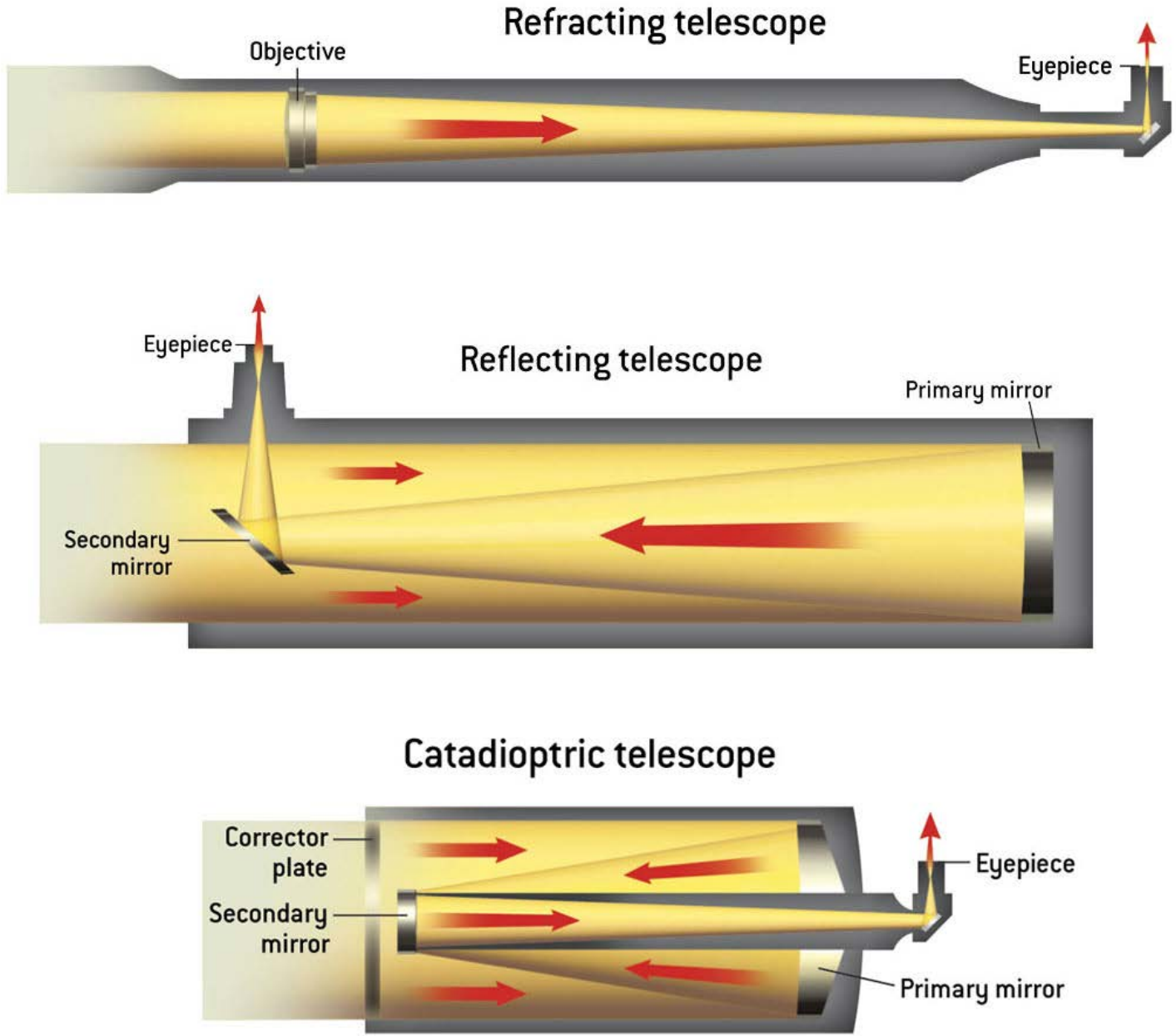
Summary…

- Different mounts are useful for different tasks
- Most amateurs go with alt-az
- Dobsonian mounts are the sturdiest and easiest to set up

Questions

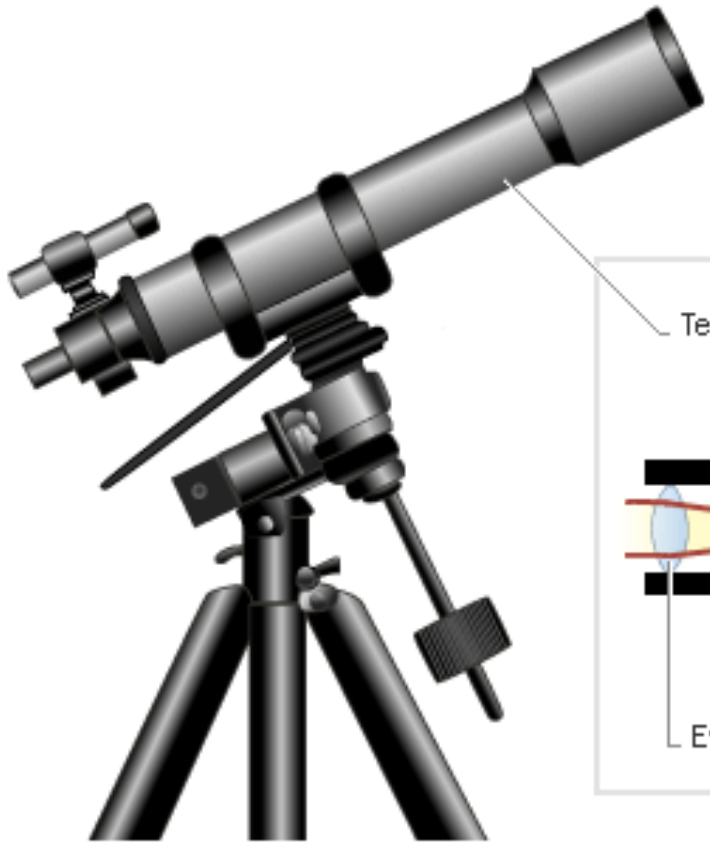
We’re going to talk about….

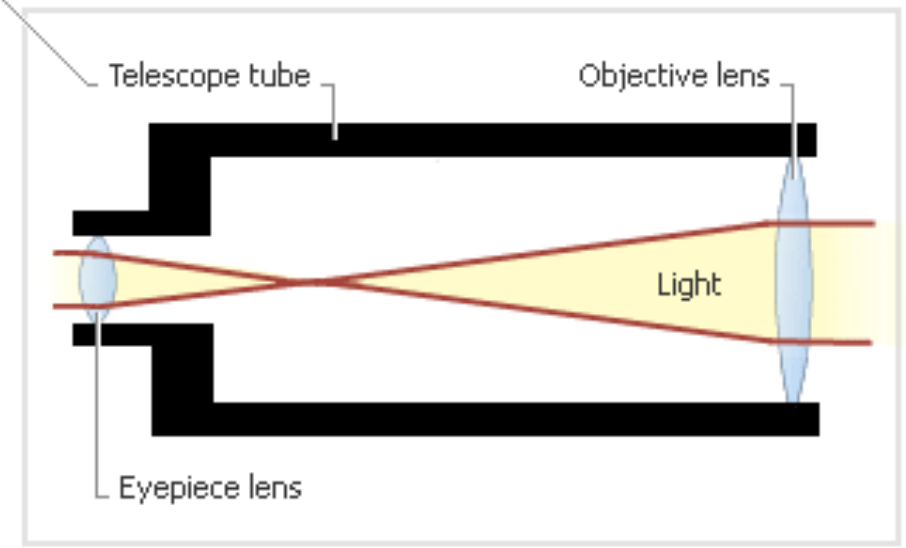
- Three major telescope designs (pros/cons)
  - Refractor
  - Reflector
    - Dobsonian
  - Schmidt-Cassegrain (SCT)



Refractors

- Refractors use lenses to collect and focus light
- First telescope invented (Hans Lippershey, 1608)
- Probably what you think of when you think “telescope”





Refractors

Refractors

Pros

- Rugged: lenses are held in place and won't come unaligned
- Sealed tube keeps out dust/debris
- Sealed tube stops air movement, gives steady view
- No obstruction

Cons

- Chromatic aberration (CA) (color distortion) from light bending at different angles when it passes through glasses
- Need a high f/ratio to overcome CA which means small lens or very heavy telescope
- Poor quality glass is horrible, high quality glass is very costly
- "Good" refractors will only be tube (optical tube assembly, OTA), cost >$500, and still need mount, eyepieces, etc.
- Generally limited to small apertures and small, bright objects
- Eyepiece ends up in odd locations when observing

Refractors

Summary

- Worst aperture per dollar cost
  - E.g. 3.5” refractor costs the same as 6” reflector
- Limited view of objects
- Not a good first choice
  - i.e. don’t bother

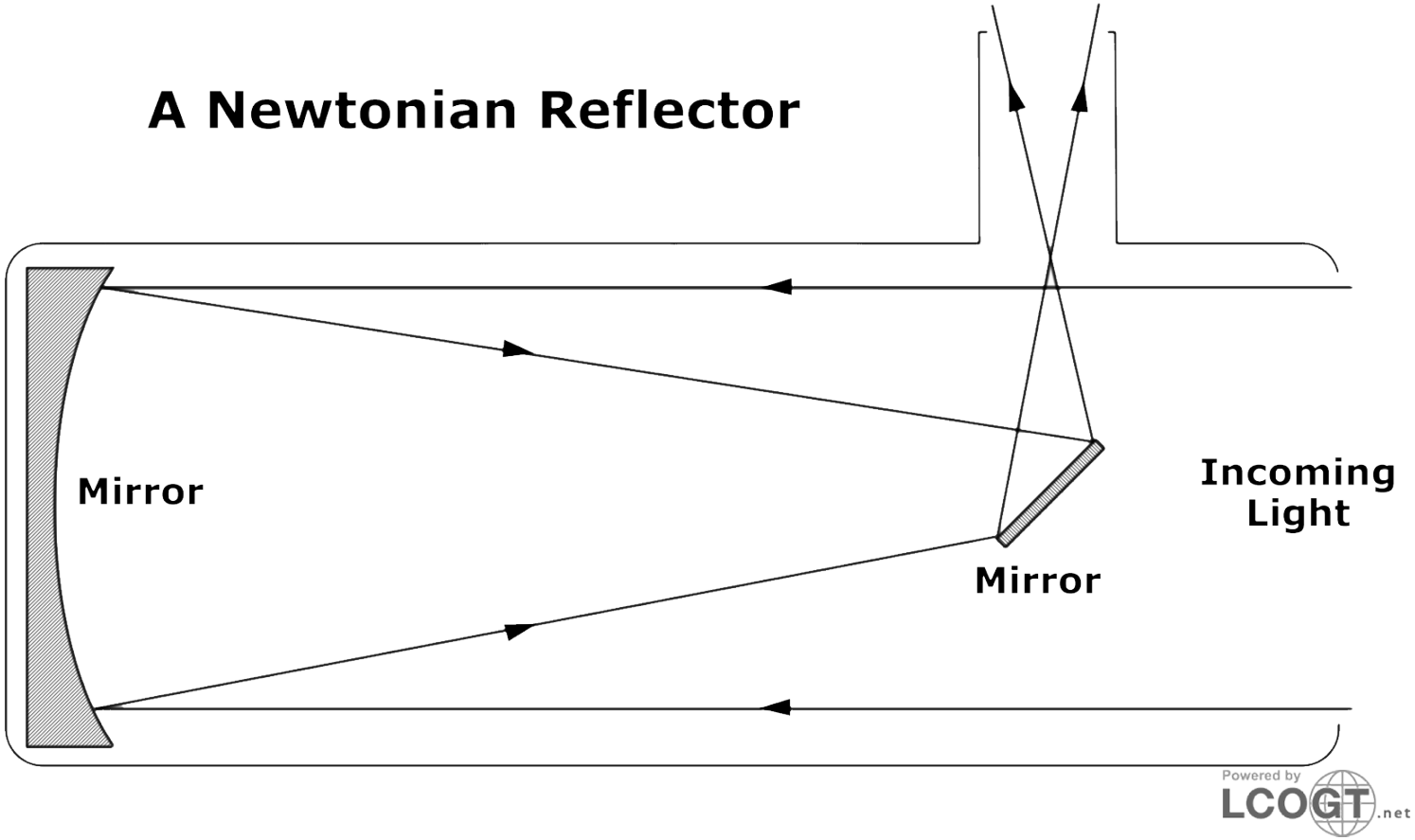
Questions

- Who’s got one?

Reflectors

- Reflectors use mirrors to collect and focus light
- Invented by Sir Isaac Newton in 1668

- Have become standard telescope for amateurs
- Can be small, medium, big, home made, off-the-shelf, in between…



Reflectors

Reflectors

Pros

- Mirrors are easy to make = lower cost for large sizes
  - Can be VERY large
- Good quality
- Good for a wide range of objects
- Usually come with good basic accessories
- Eyepieces usually in good location when observing
- Often easy set up (in seconds)
- Come in a variety of apertures and costs

Cons

- Collimation is necessary when mirrors become unaligned
- Large, long tubes
- Open tube can lead to debris if you're not careful (be careful!)
- Short focal length (>f/6) reflectors will show optical aberration called "coma"
  - Correctors are available
- Very cheap reflectors are still very cheap and will give horrendous views (beware long focal length + short tube reflectors! AKA Bird-Jones design)

Reflectors - Dobsonian

Dobsonian (Dob)

- Yes, that's also a telescope mount
- Large reflector in an alt-az mount
- Simple, easy set up
- Most common type for amateurs
- Can be made very large >16", aka "light buckets"

Reflectors

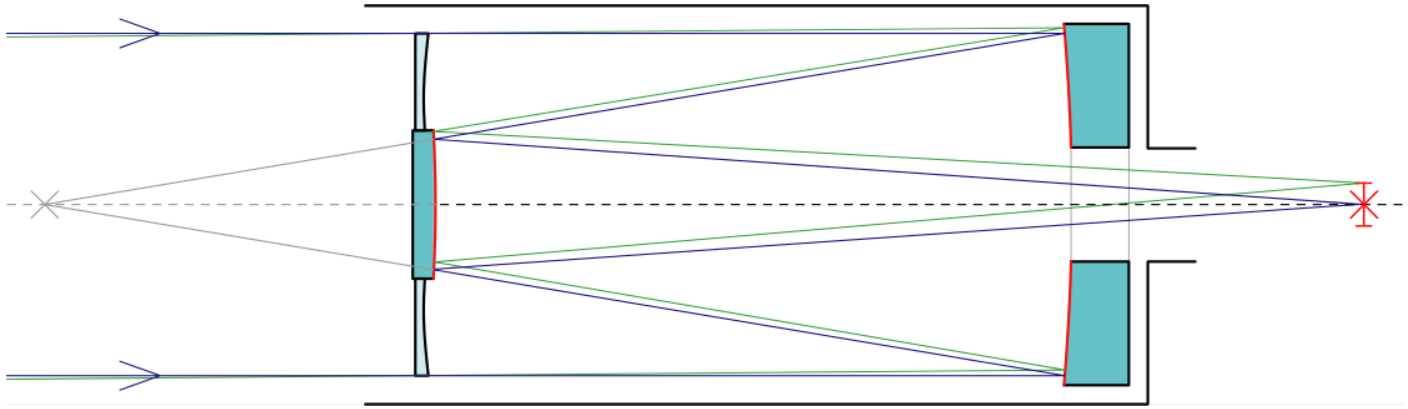
Summary

- Good all around telescope that can last you for decades of observing (aperture dependent)
- Observing Moon, planets, and fainter deep-sky objects
- Budget-conscious observers who want a lot of telescope and don't mind lugging it around
- This is most likely what you want in a telescope
  - 8" Dob reflector is most common type and will allow you to observe 99% of "exciting" objects at <$400

Questions

Schmidt-Cassegrain (SCT)

- SCTs use a combination of lenses and mirrors to collect and focus light
- Corrector lens on front bends light before it reflects off of mirror
- Corrects for aberrations in reflections
- Also other “catadioptric systems” like Maksutov–Cassegrain that act in a similar way



Schmidt-Cassegrain (SCT)

Schmidt-Cassegrain (SCT)

Pros

- Mirrors are easy to make = lower cost for large sizes
  - Can be large (12”) although never as large as a reflector
- Compact, portable, versatile
- Good for a wide range of objects
- Usually come with good basic accessories
- Eyepieces usually in good location when observing
- Often come with computerized mounts

Cons

- Weight may be too much for some people
- Collimation is necessary when mirrors become unaligned but never as necessary as with a reflector
- More expensive than reflector of same aperture
- High f/ratio can limit to small field of view observing
- Set up is usually more involved, especially with equatorial mounts
- Trade-offs like poor quality telescope mounts can limit viewing

Schmidt-Cassegrain (SCT)

Summary

- All around observing of the Moon, planets, double stars, and narrow-field views of deep-sky objects
- Good for observers with a larger budget who still want aperture but who favor portability

Telescope Designs

Summary….

- Unless you have a special need for one, ignore refractors
- Reflectors give the best aperture-to-dollar cost
- SCTs are great for portability but will cost you more

Questions

Things to consider when looking at a telescope

- What's the aperture?
  - How much detail am I going to see?
  - Is it going to show me what I want to see?
- How much does it weigh / how physically big is it?
  - Can I move it around? Do I have a place to store it?
- How much does it cost?
- Is the mount stable and easy to use?
  - How much time do I want to spend setting it up?

So if you were still wondering about…

- What telescope should I buy?
- 6” or 8" Dobsonian telescope
- Costs around $400
- Large but very stable
- Available from…
  - Orion
    - XT6, XT8
  - Apertura
    - AD8
  - Skywatcher
    - 6" Traditional Dobsonian
    - 8" Collapsible
  - Zhumell
    - Z8 Deluxe Dobsonian Reflector Telescope
- Available wherever you have an internet connection

Questions

Other links of interest

- www.cloudynights.com
- www.skyandtelescope.com
- www.Astronomy.com
- www.reddit.com/r/telescopes
- www.bessermuseum.org/sky-theater

- Books
  - Turn Left at Orion
  - The Backyard Astronomer's Guide
  - NightWatch: A Practical Guide to Viewing the Universe
  - Pocket Sky Atlas

- thaddeus@bessermuseum.org