Distance measurement of stars

Medium of Observation: Electromagnetic Radiation

Elementary particles + Nuclei

Light:

Ray optics (pretending light travels in straight lines)

Deductions

1) Radius of orbit, $1.5 \times 10^{11}$ m = 1 AU (average)

2) $\angle \theta = \frac{2 \pi \text{ rad}}{D}$

$\frac{2 \pi \text{ rad}}{D} \rightarrow D = \frac{2 \pi \text{ rad}}{\theta}$

1 ly $\approx 10^{16}$ m

2 $\pi$ rad $= 360^\circ$

$1^\circ = 60'$

1' $= 60''$

Measurement of $\theta$ requires very precise measuring equipment

1 parsec = $1 \text{ AU} = 3 \times 10^{16}$ m (roughly 3 ly)

$\frac{1}{1''} = 2.061265 \text{ AU}$
II. How bright something appears with distance

\[ \text{Intensity (D_2)} = I(D_1) \cdot \frac{D_1^2}{D_2^2} \]

On Earth, \( I_\odot = \frac{1.3}{m^2} \) kW

**Measure of Brightness: Magnitude**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>super bright</td>
</tr>
<tr>
<td>0</td>
<td>really bright</td>
</tr>
<tr>
<td>5</td>
<td>kind of bright</td>
</tr>
<tr>
<td>10</td>
<td>very faint need telescope</td>
</tr>
</tbody>
</table>

\( M_\odot = -26.83 \)

Brightness is log-based log-scale

**Apparent** \( m = 2.5 \log \left( \frac{I_{[\text{m}^2 \text{W}]} \text{W}}{m} \right) \)

**Absolute** \( M = m - 5 \log \left( \frac{1 \text{pc}^2}{r^2} \right) = m + 5 \log \left( \frac{10 \text{pc}}{r} \right) \)
Electromagnetic Waves

Light Wave Approach

plane wave \( \vec{E}(t, \vec{r}) = \vec{E}_0 \cos (\vec{k} \cdot \vec{r} - \omega t) \)

\( \vec{k} \) = direction of propagation

\( \vec{k} \equiv \begin{cases} \frac{2\pi}{\lambda} \\
\frac{2\pi f}{c} \end{cases} \)

\* in vacuum \( \frac{\omega}{k} = c \)

\( \vec{E}_0 \perp \vec{k} \)

\( \vec{B} \) in phase w/ \( \vec{E} \)

\( \vec{B} = \frac{1}{c} \vec{k} \times \vec{E} \)

\( \nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0} \)

\( \nabla \cdot \vec{B} = 0 \)

\( \nabla \times \vec{B} = -\frac{1}{c} \frac{\partial \vec{E}}{\partial t} \)

\( \nabla \times \vec{E} = \mu_0 \varepsilon_0 \frac{\partial \vec{B}}{\partial t} \)

Maxwell’s equations explain why electric and magnetic fields are transverse, their relationship to each other, and why the phase velocity is the speed of light.