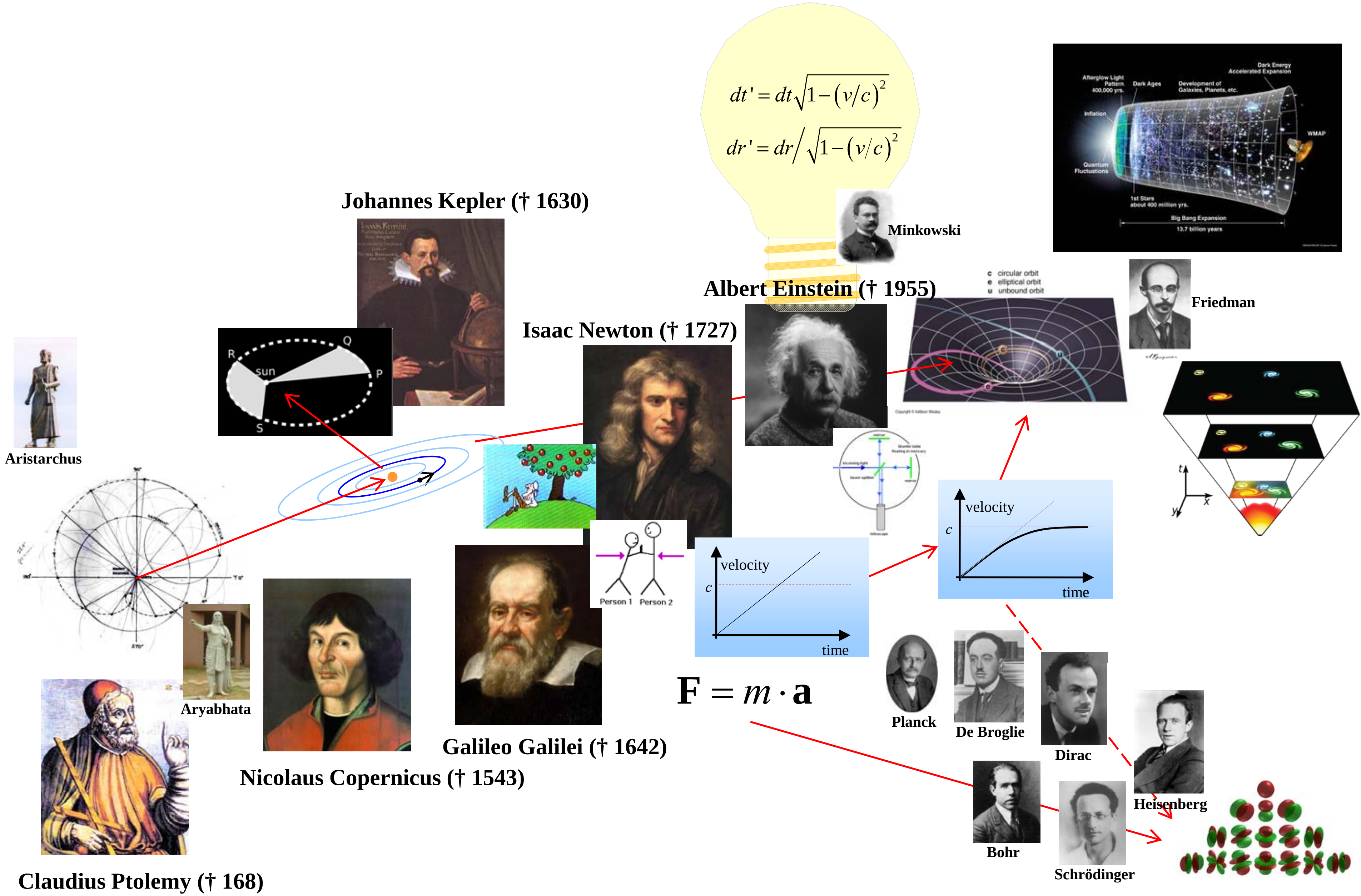
The Dynamic Universe - from whole to local

- **From Ptolemy skies to FLRW cosmology**
- **Hierarchy of physical quantities and theory structures**
- **The Dynamic Universe: The overall energy balance – cosmological and local consequences**
- **Conclusions**

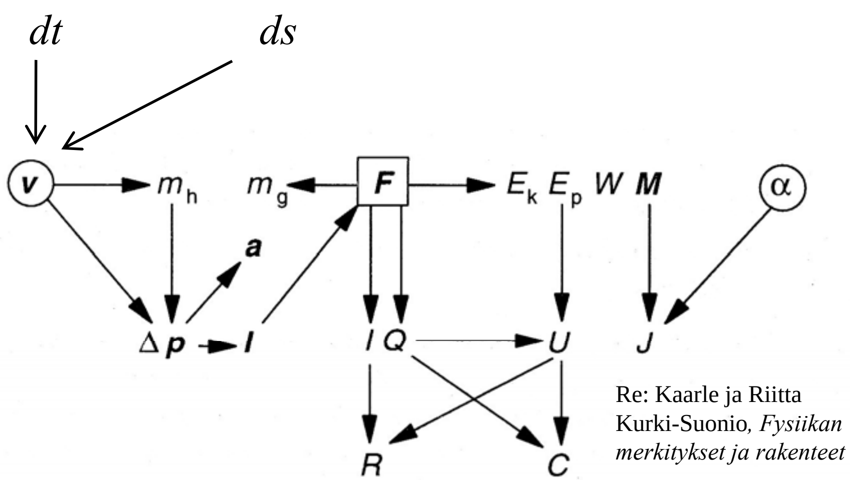
From Earth centered to everywhere-centered universe



Hierarchy of physical quantities and theory structures

Contemporary physics

time [s] distance [m]



Re: Kaarle ja Riitta Kurki-Suonio, *Fysiikan merkitykset ja rakenteet*

Cosmology

- Redefinition of time and distance
- Constancy of the velocity of light
- Relativity principle
- Equivalence principle
- Cosmological principle
- Lorentz invariance

Celestial mechanics

Relativity and gravitation are expressed in terms of modified metrics

Relativity between object and observer

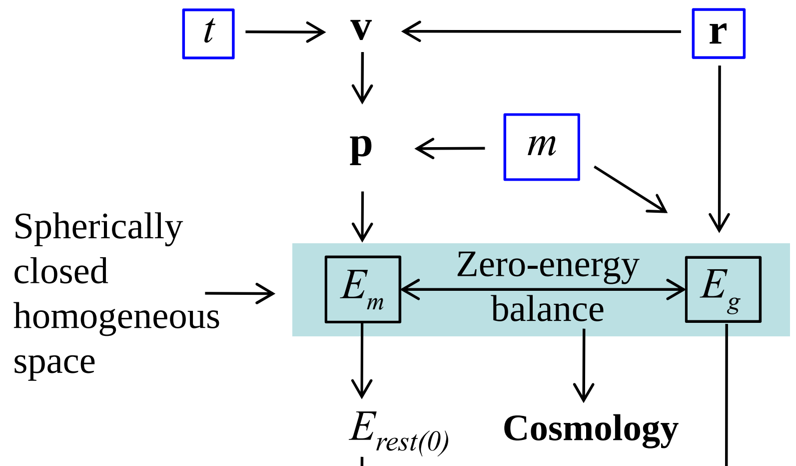
- Maxwell equation
- Planck equation
- QM basis:

Dirac / Klein-Gordon

Schrödinger equation

Dynamic Universe

time [s] substance [kg] distance [m]



Conservation of total energy in local structure buildup

$E_{rest(local)}$ $E_{g(local)}$

E_{kin}

$E_{Coulomb}$ → Thermodynamics, Electromagnetism, Celestial mechanics

$E_{radiation}$

Relativity is expressed in terms of locally available energy

Relativity between local and the whole

$$m \equiv h_0/\lambda \qquad h_0 = \chi_\lambda \cdot 2\pi^3 e^2 \mu_0 \quad (= h/c) \; [\text{kgm}]$$

QM basis: Resonant mass wave structures

The Dynamic Universe

- Spherically closed space, zero-energy balance of motion and gravitation
- Buildup of total energy in spherically closed homogeneous space

In search of the structure of space …

Einstein 1917, ”Cosmological considerations of the general theory of relativity”

Thus the newly introduced universal constant λ defines both the mean density of distribution ρ which can remain in equilibrium and also the radius R and the volume $2\pi^2R^3$ of spherical space. The total mass M of the universe, according to our view, is finite, and is in fact

$$M = \rho \,.\, 2\pi^2R^3 = 4\pi^2\frac{R}{\kappa} = \pi^2\sqrt{\frac{32}{\kappa^3\rho}} \quad . \quad . \quad (15)$$

Thus the theoretical view of the actual universe, if it is in correspondence with our reasoning, is the following. The

188 COSMOLOGICAL CONSIDERATIONS

curvature of space is variable in time and place, according to the distribution of matter, but we may roughly approximate to it by means of a spherical space. At any rate, this view is logically consistent, and from the standpoint of the general theory of relativity lies nearest at hand; whether, from the standpoint of present astronomical knowledge, it is tenable, will not here be discussed. In order to arrive at this consistent view, we admittedly had to introduce an extension of the field equations of gravitation which is not justified by our actual knowledge of gravitation. It is to be emphasized, however, that a positive curvature of space is given by our results, even if the supplementary term is not introduced. That term is necessary only for the purpose of making possible a quasi-static distribution of matter, as required by the fact of the small velocities of the stars.

Feynman ” Lectures on gravitation in 1960’ ”

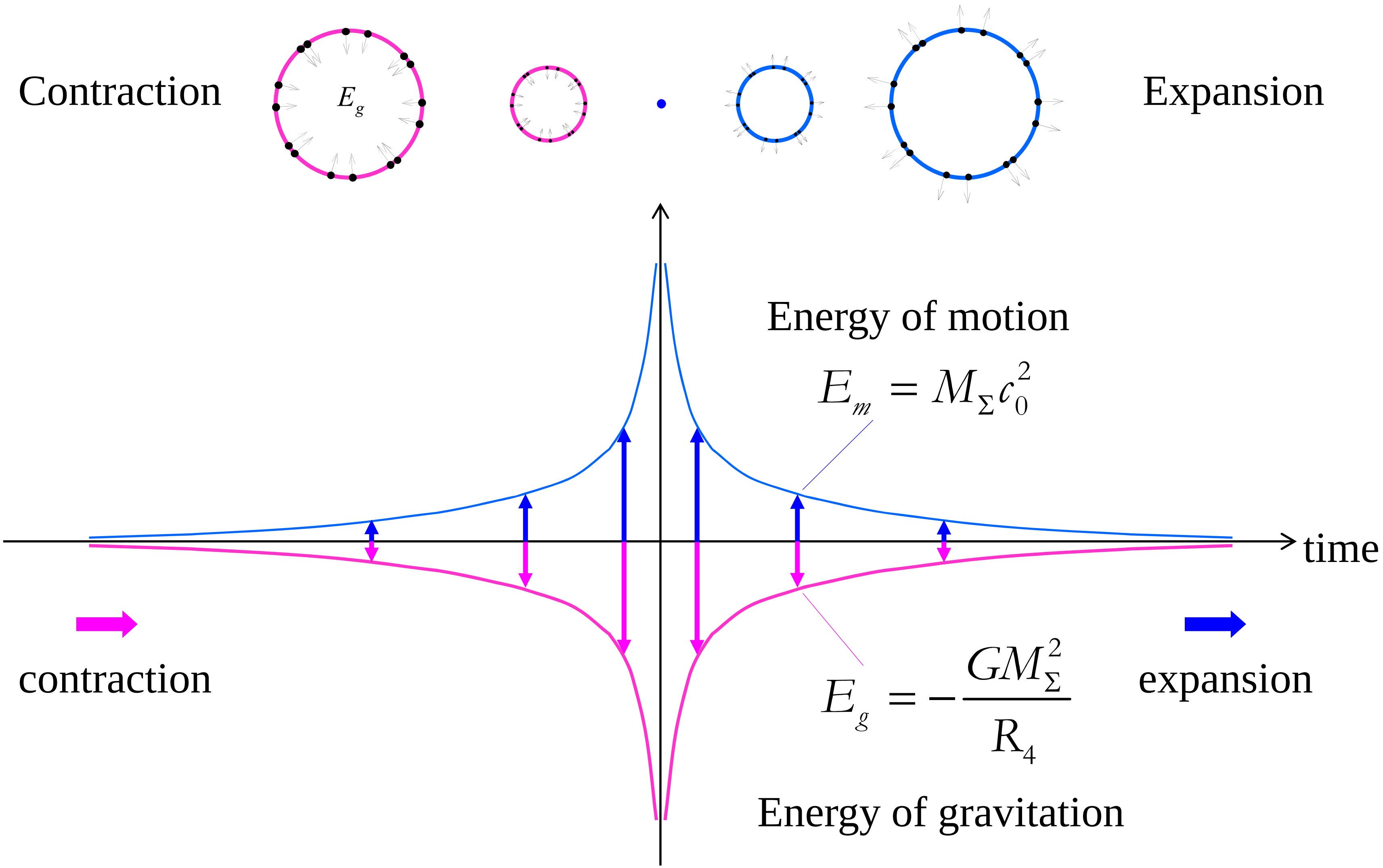
In search of a finite structure …

“...One intriguing suggestion is that the universe has a structure analogous to that of a spherical surface. If we move in any direction on such a surface, we never meet a boundary or end, yet the surface is bounded and finite. It might be that our three-dimensional space is such a thing, a tridimensional surface of a four sphere. The arrangement and distribution of galaxies in the world that we see would then be something analogous to a distribution of spots on a spherical ball.”

… and energy balance in space …

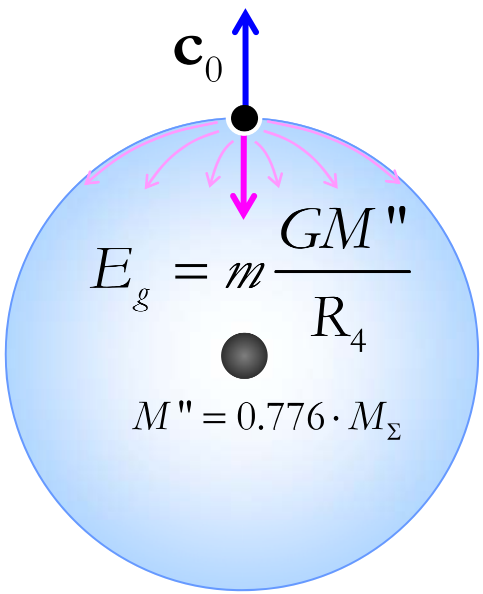
… If now we compare the total gravitational energy $E_g = GM^2_{tot}/R$ to the total rest energy of the universe, $E_{rest} = M_{tot}c^2$, lo and behold, we get the amazing result that $GM^2_{tot}/R = M_{tot}c^2$, so that the total energy of the universe is zero....
— Why this should be so is one of the great mysteries — and therefore one of the important questions of physics. After all, what would be the use of studying physics if the mysteries were not the most important things to investigate”

Zero-energy balance of motion and gravitation



Zero-energy balance of motion and gravitation

$$E_m = c_0 \left|\mathbf{p}\right| = c_0 \left|m\mathbf{c}\right| = mc_0^2$$



$$c_0^2 = \frac{GM"}{R_4}$$

Zero-energy balance of motion and gravitation

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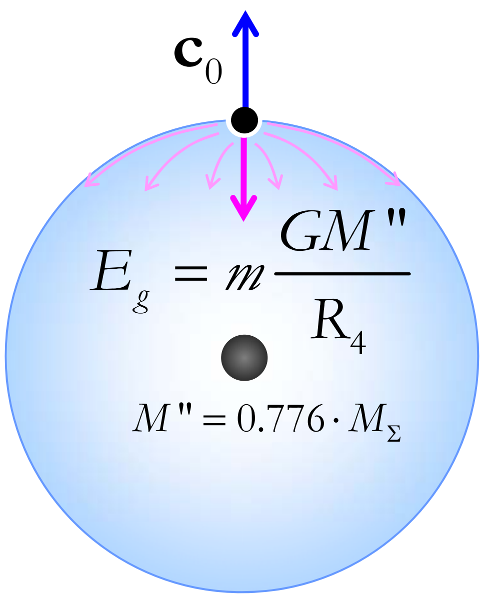
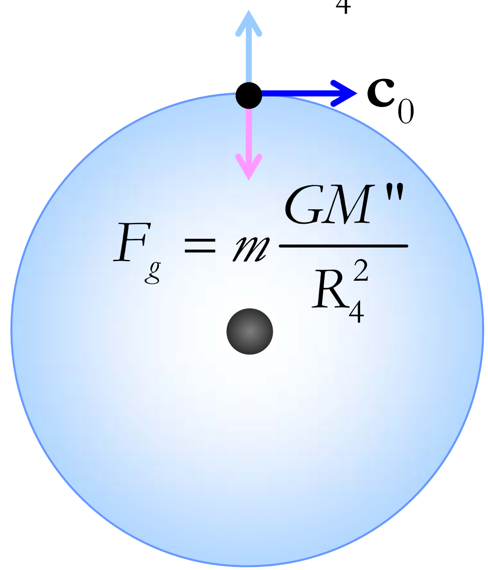


$$E_g = m\frac{GM''}{R_4}$$

$$M'' = 0.776 \cdot M_\Sigma$$

$$F_C = m\frac{c_0^2}{R_4}$$



$$F_g = m\frac{GM''}{R_4^2}$$

$$c_0^2 = \frac{GM''}{R_4}$$

The Dynamic Universe

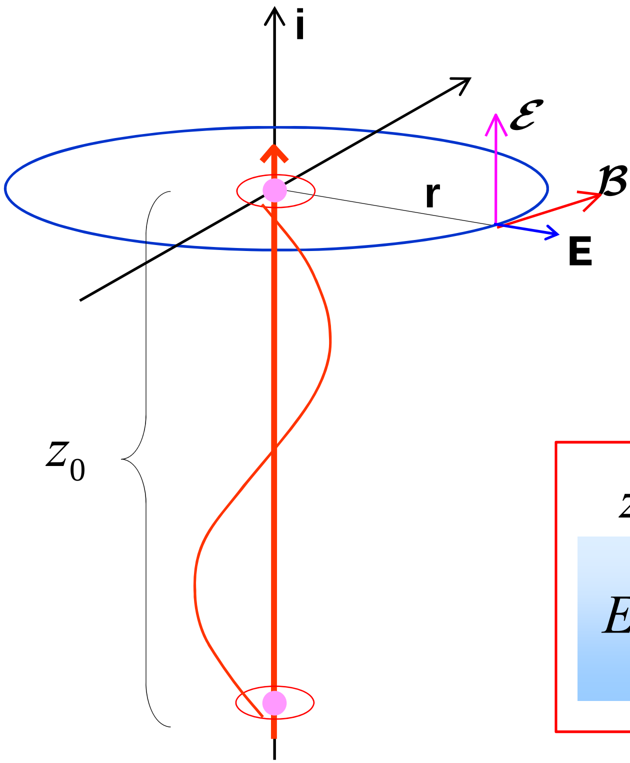
- Mass as wavelike substance for the expression of energy
- Unified expression of energy

Quantum as the minimum dose of electromagnetic radiation

“A radio engineer can hardly think about smaller amount of electromagnetic radiation than emitted by a single oscillation cycle of a unit charge in a dipole.“

1. We solve Maxwell’s equation for the energy of one cycle of radiation emitted by a single electron transition in a dipole
2. We apply the solution to a point source as a dipole in the fourth dimension
3. We apply the result for a unified expression of energies

The energy of one wavelength of radiation emitted by a dipole



$$P=\left\langle \frac{dE}{dt}\right\rangle =\int_s c\,\mathsf{E}_{ave}\,dS=\frac{\Pi_0^2\chi\mu_0\omega^4}{32\pi^2r^2c}\int_s \sin^2\theta\,dS=\frac{\Pi_0^2\chi\mu_0\omega^4}{12\pi c}$$

$$E_\lambda=\frac{P}{f}=\frac{N^2e^2z_0^2\chi\mu_0 16\pi^4f^4}{12\pi cf}=N^2\left(\frac{z_0}{\lambda}\right)^2\frac{2}{3}\left(2\chi_\lambda\pi^3e^2\mu_0c\right)f$$

$$z_0=\lambda,\ N=1$$

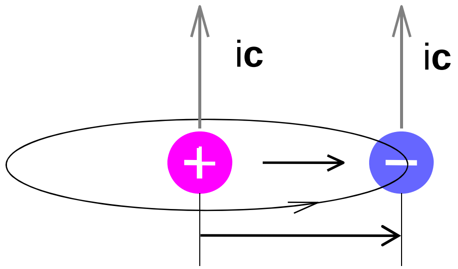
$$E_\lambda=2\chi_\lambda\pi^3e^2\mu_0 c\cdot f=hf=h_0\cdot cf=\frac{h_0}{\lambda}\cdot c^2=m_\lambda c^2$$

h [kg]

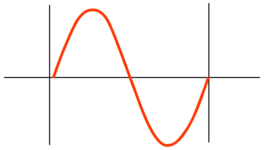
$$\alpha=\frac{e^2\mu_0}{2h_0}=\frac{1}{2\cdot\chi_\lambda 2\pi^3}=\frac{1}{1.1042\cdot 4\pi^3}\approx\frac{1}{137}$$

Unified expression of energy

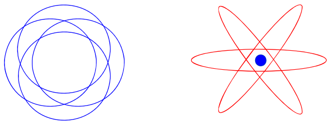
Coulomb energy $$E_c = \frac{q_1 q_2 \mu_0}{4\pi r} c_0 c = N_1 N_2 \alpha \frac{h_0}{2\pi r} c_0 c = c_0 m_c c$$



A unit cycle of radiation $$E_\lambda = c_0 \left|\mathbf{p}\right| = \frac{h_0}{\lambda} c c_0 = c_0 m_\lambda c$$



The rest energy of mass $$E_{rest} = c_0 \left|\mathbf{p}_4\right| = c_0 m c = c_0 \frac{h_0}{\lambda_m} c$$



Kinetic energy $$E_{kin} = c_0 \left|\Delta \mathbf{p}_{tot}\right| = c_0 \left(m\Delta c + c\Delta m\right) = c_0 \left(\frac{h_0}{\lambda_m}\Delta c + c\Delta\left(\frac{h_0}{\lambda}\right)\right)$$

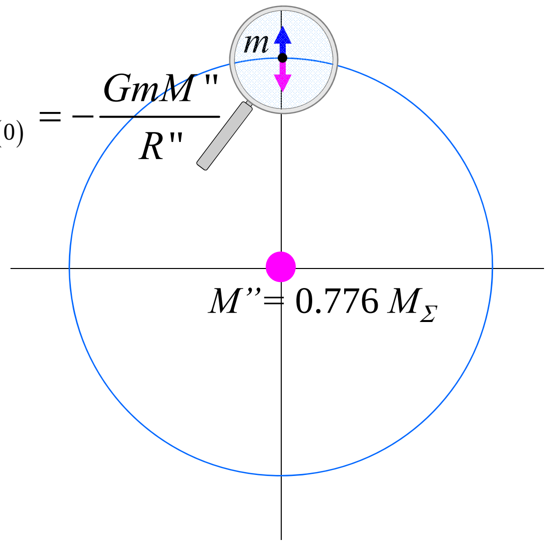
The Dynamic Universe

- Conservation of energy in the buildup of local structures in space
- The system of nested energy frames

Zero-energy balance of motion and gravitation

$$E''_{m(0)} = c_0 \left|\mathbf{p}\right| = c_0 m c_0$$

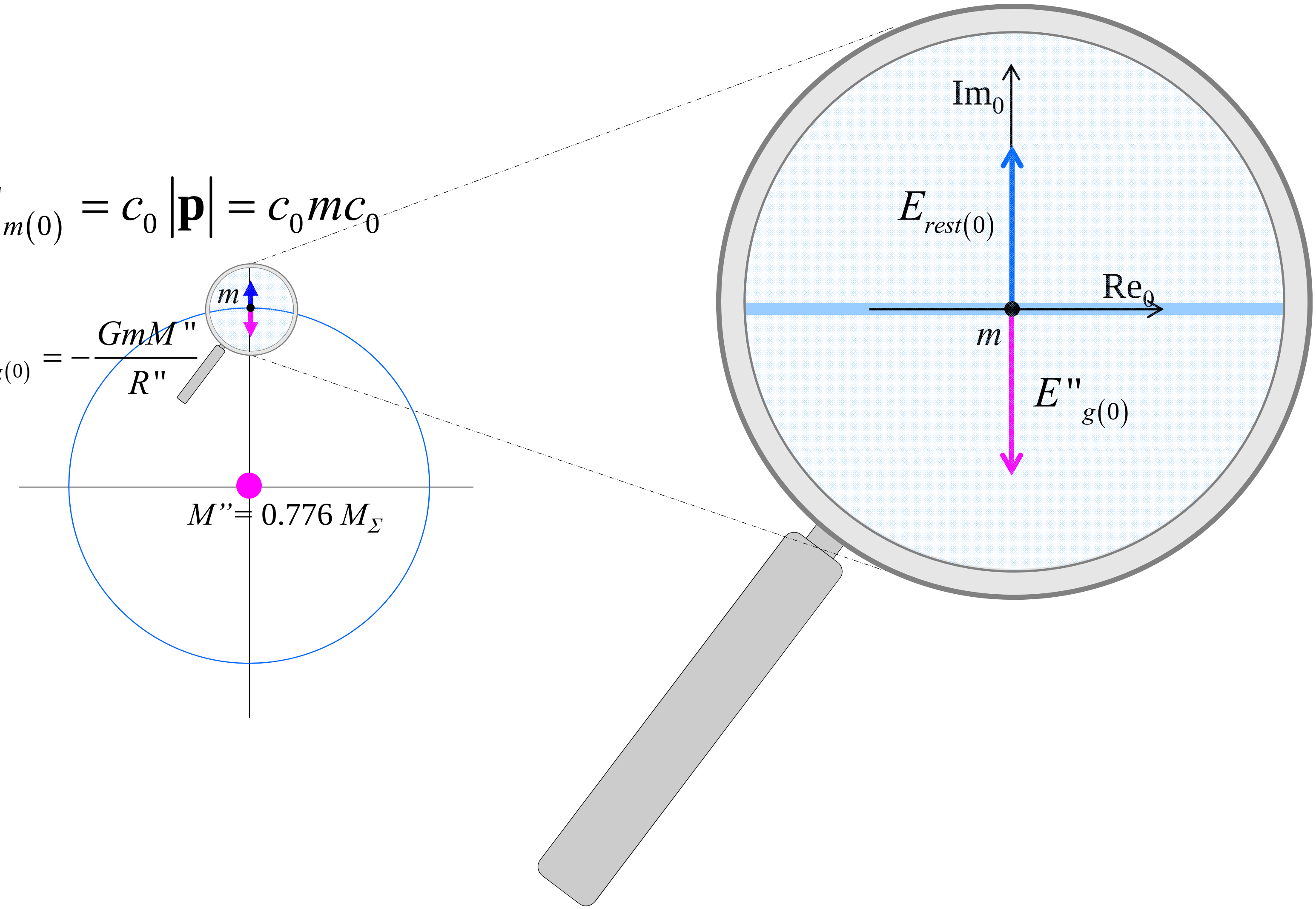
$$E''_{g(0)} = -\frac{GmM''}{R''}$$



Conservation of energy in interactions in space

$$E''_{m(0)} = c_0 \left|\mathbf{p}\right| = c_0 m c_0$$

$$E''_{g(0)} = -\frac{GmM''}{R''}$$



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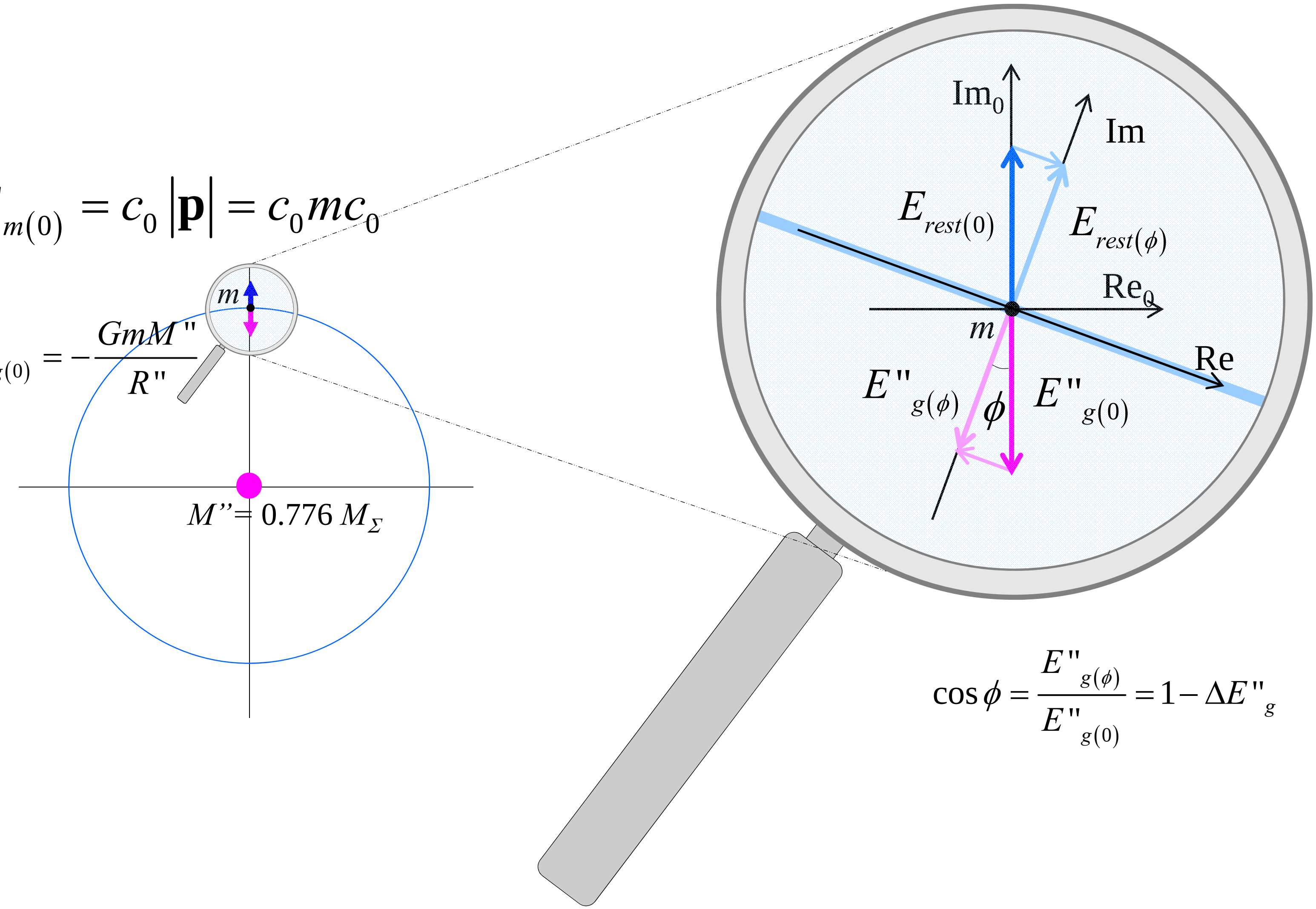
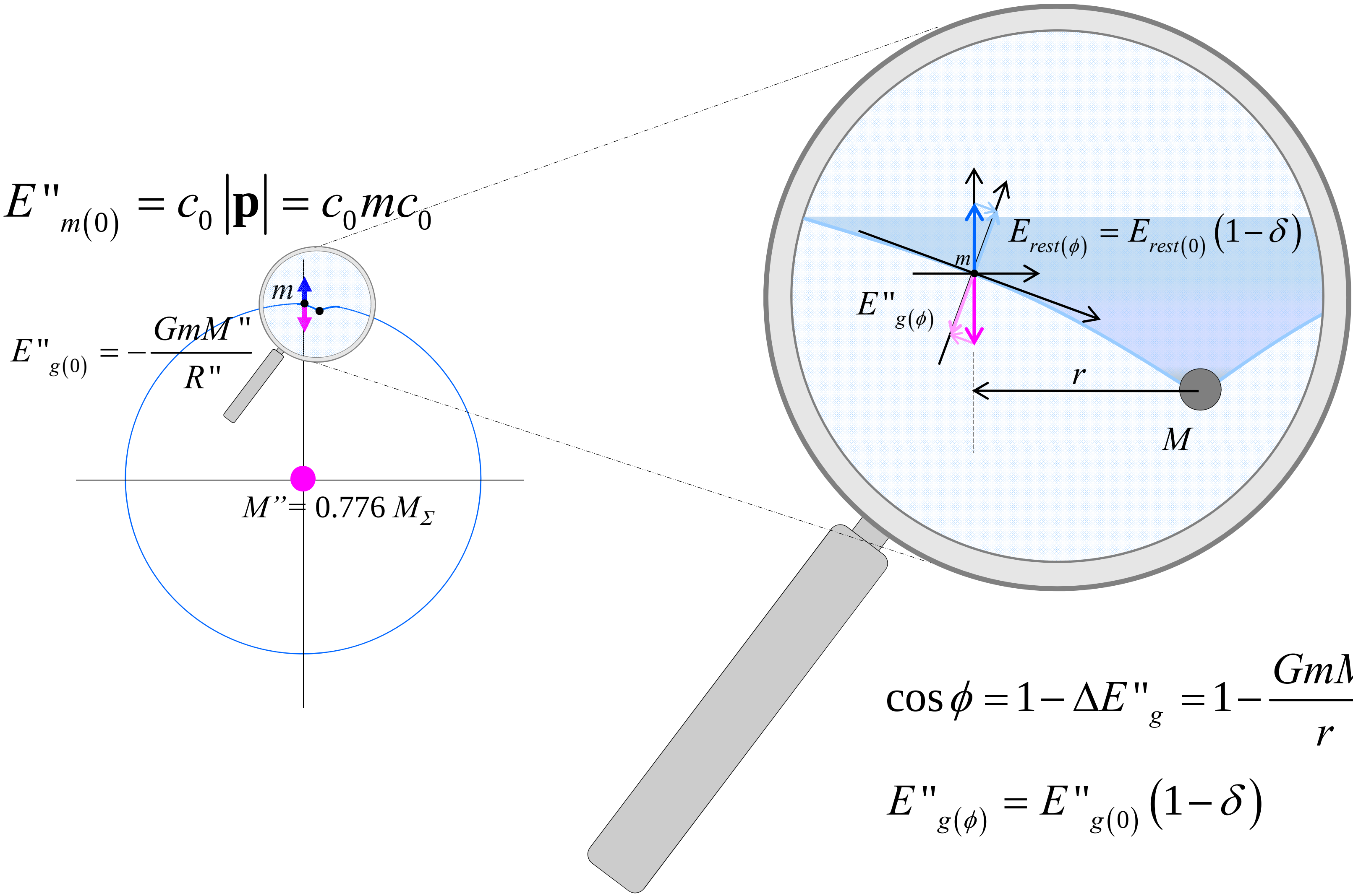


$$\cos\phi = \frac{E''_{g(\phi)}}{E''_{g(0)}} = 1 - \Delta E''_g$$

Conservation of energy in interactions in space

$$E''_{m(0)} = c_0 |\mathbf{p}| = c_0 m c_0$$



$$\cos\phi = 1 - \Delta E''_g = 1 - \frac{GmM}{r} = 1 - \delta$$

$$E''_{g(\phi)} = E''_{g(0)}(1-\delta)$$

Conservation of energy in interactions in space

$$E''_{m(0)} = c_0 \left|\mathbf{p}\right| = c_0 m c_0$$

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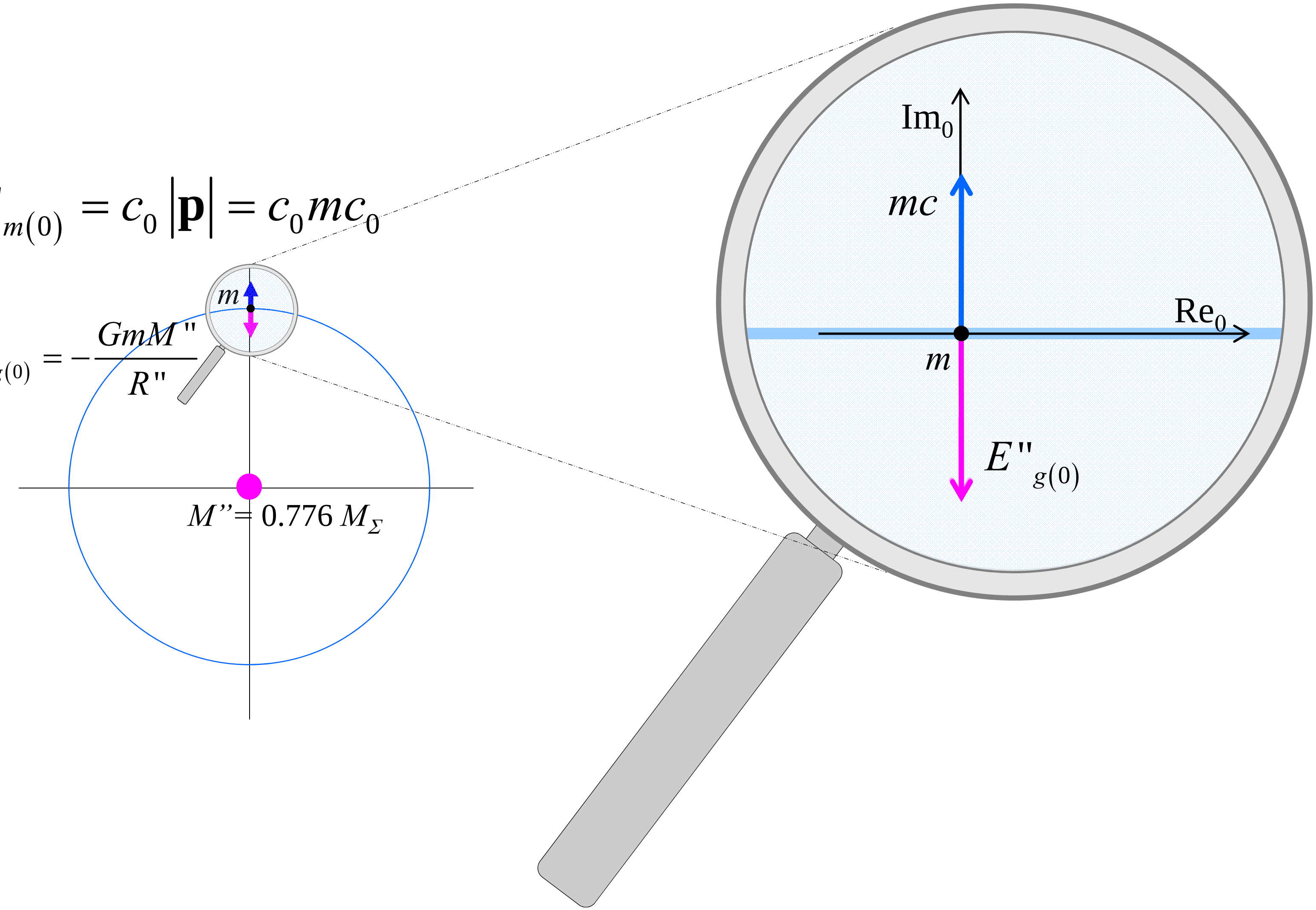

Conservation of energy in interactions in space

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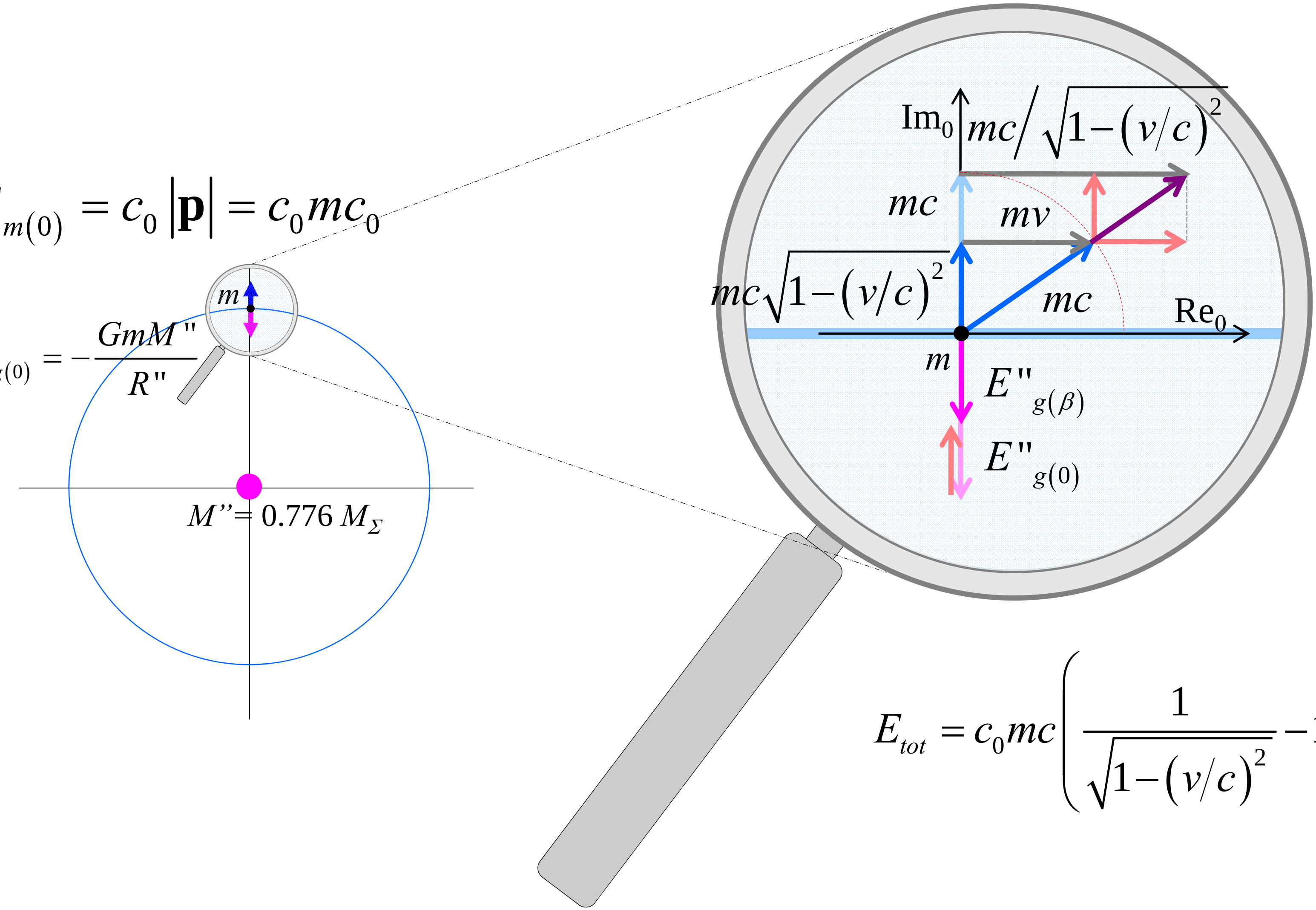

$$E_{tot} = c_0 mc\left(\frac{1}{\sqrt{1-(v/c)^2}} - 1\right)$$

Conservation of energy in interactions in space

$$E''_{m(0)} = c_0 \left|\mathbf{p}\right| = c_0 m c_0$$

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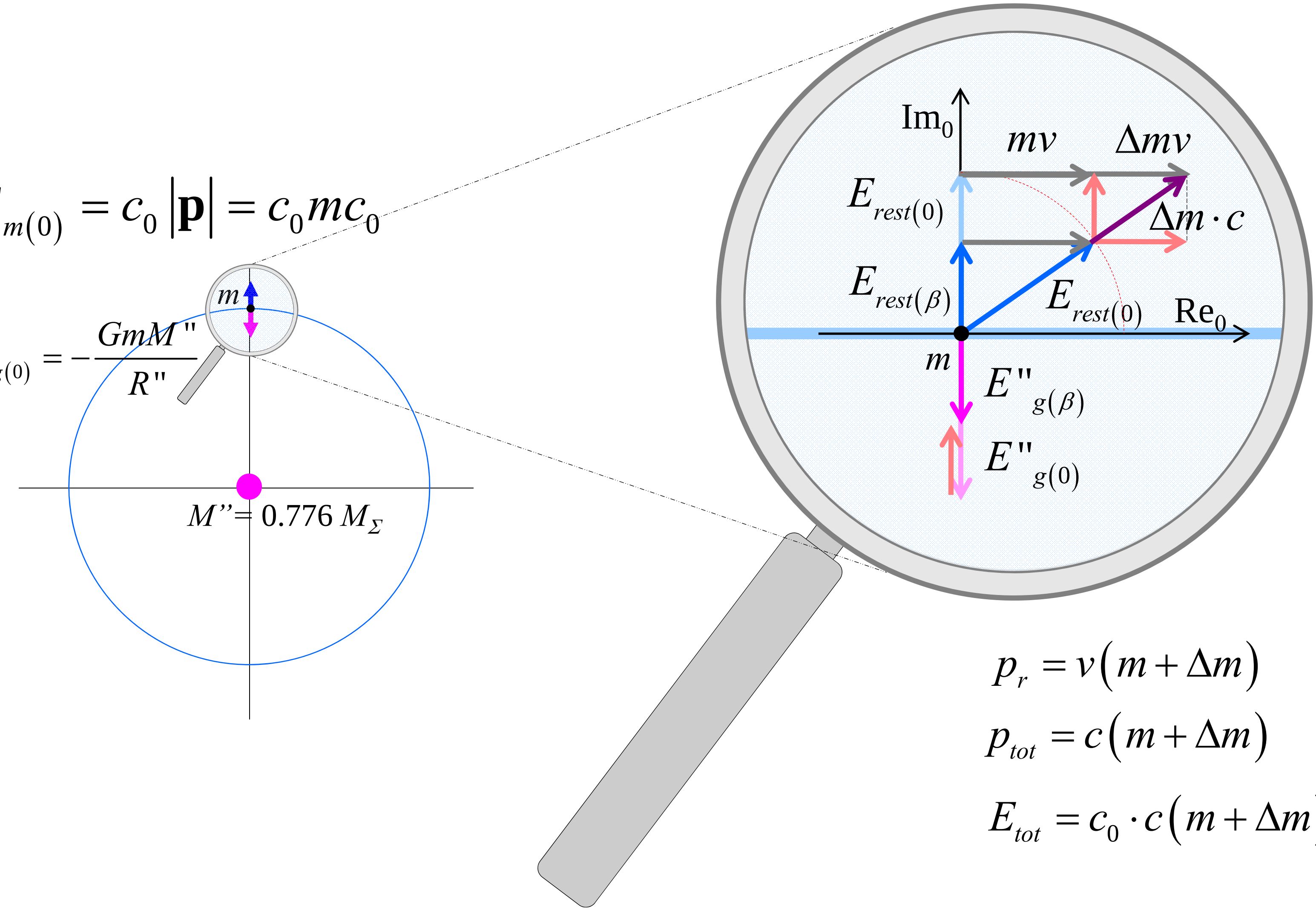


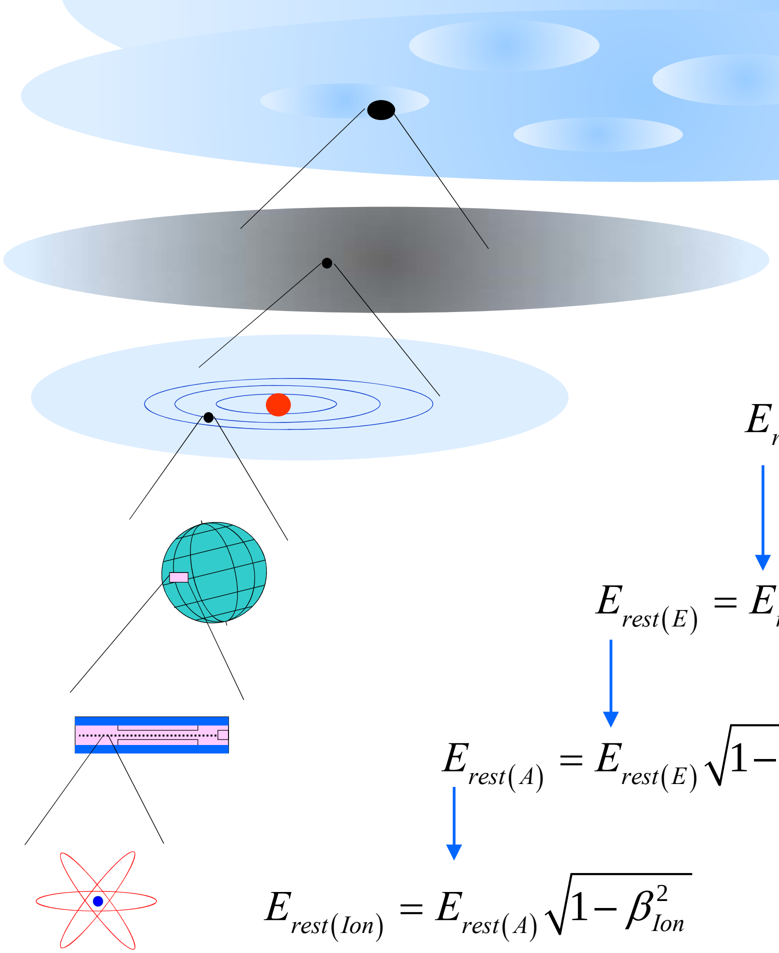
$$p_r = v\left(m + \Delta m\right)$$

$$p_{tot} = c\left(m + \Delta m\right)$$

$$E_{tot} = c_0 \cdot c\left(m + \Delta m\right)$$

The system of nested energy frames

Hypothetical homogeneous space



$$E_{rest(0,0)} = m_0 c_0^2$$

$$E_{rest(XG)} = E_{rest(0,0)}\left(1-\delta_{XG}\right)\sqrt{1-\beta_{XG}^2}$$

$$E_{rest(MW)} = E_{rest(XG)}\left(1-\delta_{MW}\right)\sqrt{1-\beta_{MW}^2}$$

$$E_{rest(S)} = E_{rest(MW)}\left(1-\delta_{S}\right)\sqrt{1-\beta_{S}^2}$$

$$E_{rest(E)} = E_{rest(S)}\left(1-\delta_{E}\right)\sqrt{1-\beta_{E}^2}$$

$$E_{rest(A)} = E_{rest(E)}\sqrt{1-\beta_{A}^2}$$

$$E_{rest(Ion)} = E_{rest(A)}\sqrt{1-\beta_{Ion}^2}$$

$$E_{rest(n,n)} = E_{rest(0,0)}\prod_{i=1}^{n}\left(1-\delta_{i}\right)\sqrt{1-\beta_{i}^2}$$

Clocks in DU space

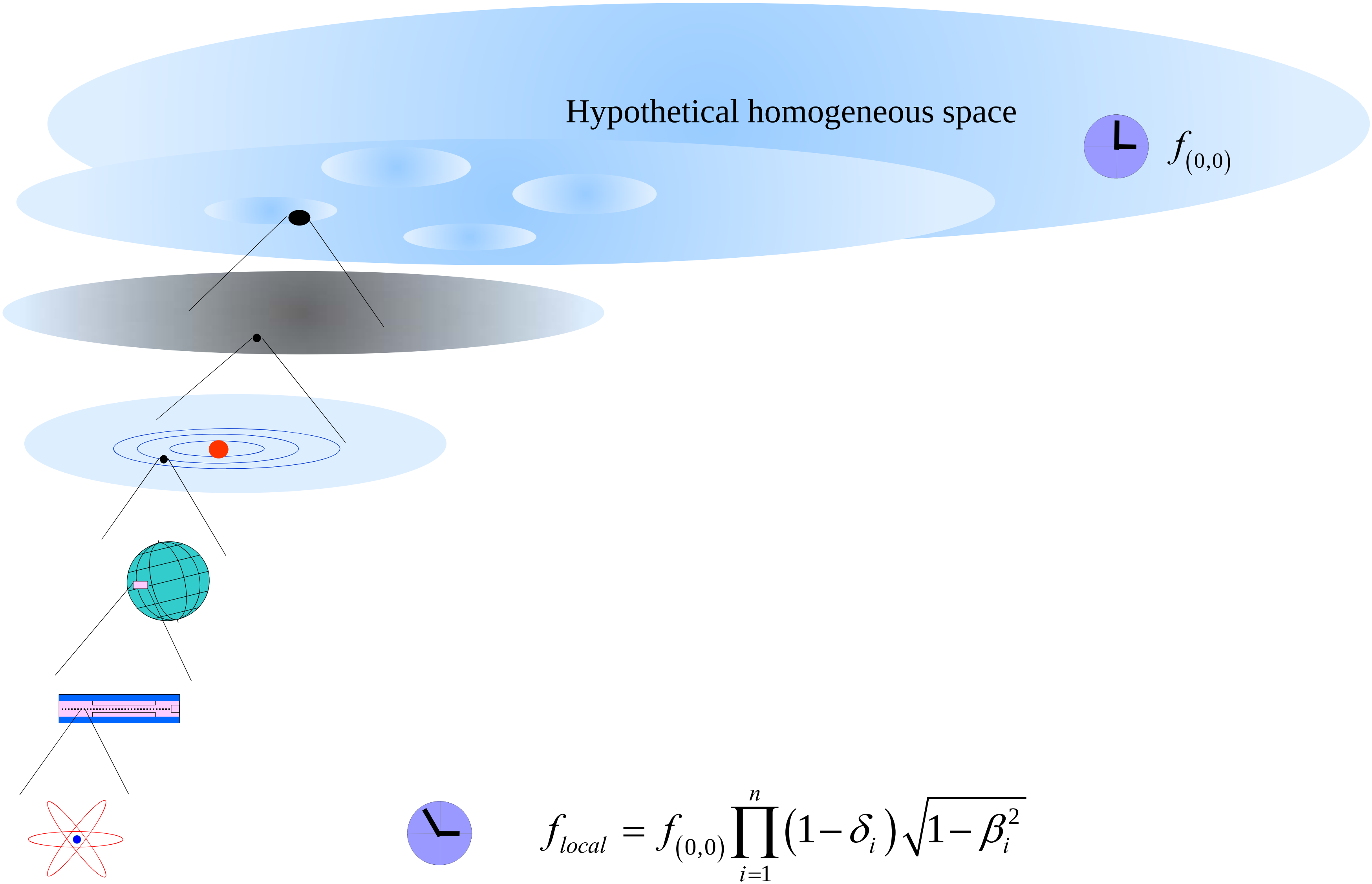
Substitution of the rest energy of electron

$$E_{rest(n,4)} = E_{rest(0)} \prod_{i=1}^{n} \left(1-\delta_i\right) \sqrt{1-\beta_i^2}$$

into Balmer's equation results in characteristic frequencies of atomic clocks

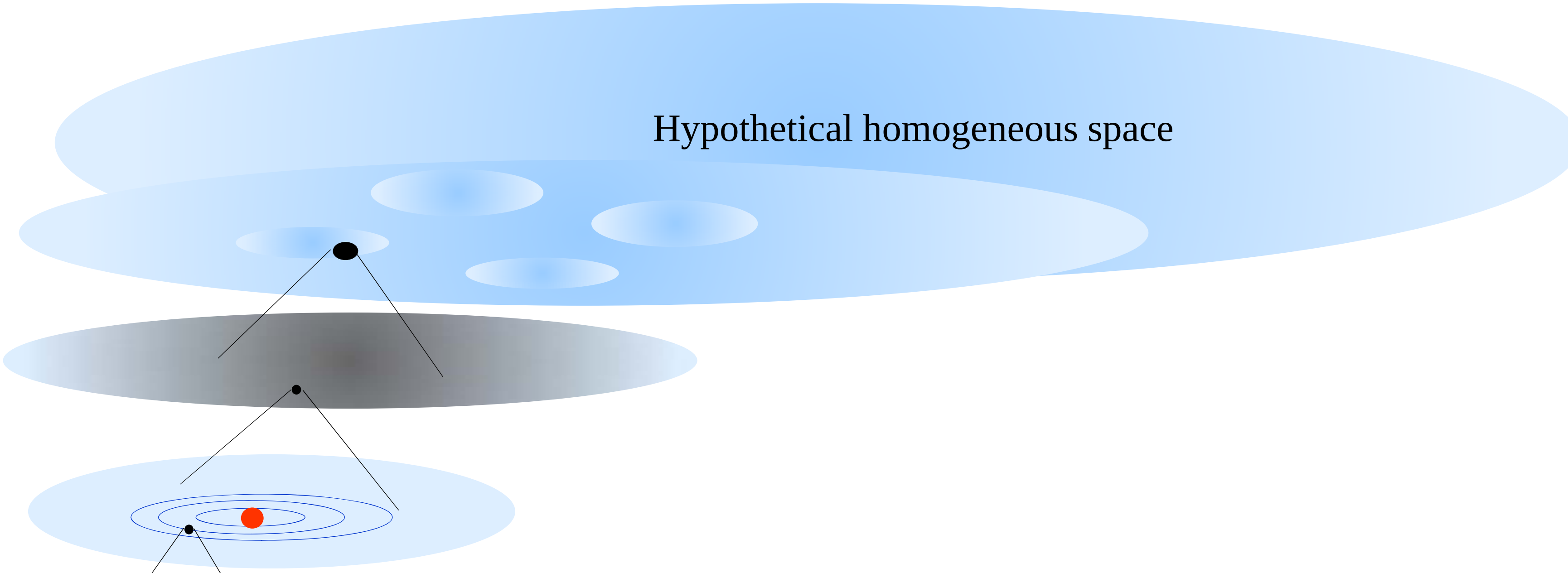
$$f_{local} = f_{(0,0)} \prod_{i=1}^{n} \left(1-\delta_i\right) \sqrt{1-\beta_i^2}$$

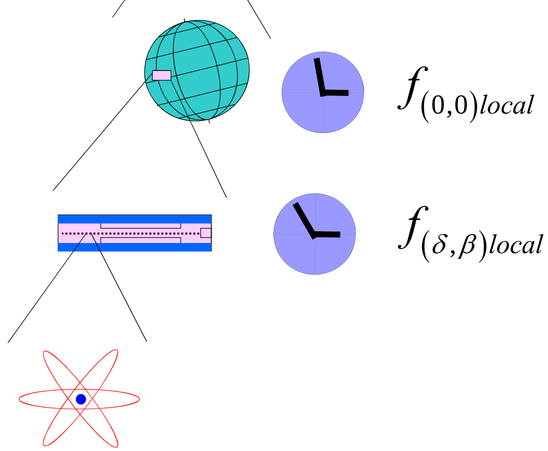
The system of nested energy frames



$$f_{local} = f_{(0,0)} \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2}$$

The system of nested energy frames

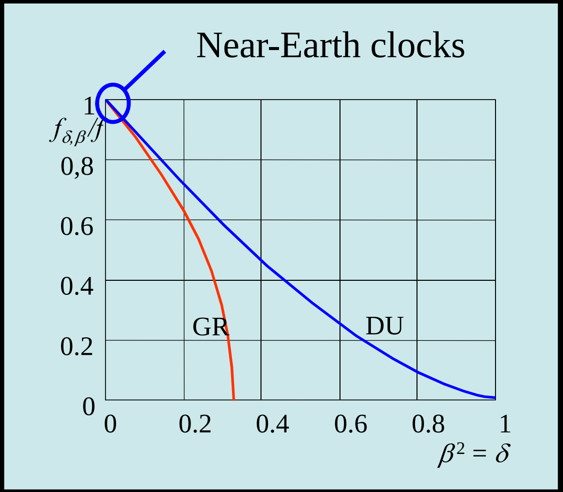




DU: $$f_{(\delta,\beta)local} = f_{(0,0)local}\left(1-\delta\right)\sqrt{1-\beta^2}$$

GR: $$f_{(\delta,\beta)local} = f_{(0,0)local}\sqrt{1-2\delta-\beta^2}$$

Satellite in Earth gravitational frame (ECI frame)



$$f_{(DU)} = f_{0,0}\left(1-\delta\right)\sqrt{1-\beta^2} \approx f_{0,0}\left(1-\delta-\frac{1}{2}\beta^2-\frac{1}{8}\beta^4+\frac{1}{2}\delta\beta^2\right)$$

$$f_{(GR)} = f_{0,0}\sqrt{1-2\delta-\beta^2} \approx f_{0,0}\left(1-\delta-\frac{1}{2}\beta^2-\frac{1}{8}\beta^4-\frac{1}{2}\delta\beta^2\right)$$

Experiments with atomic oscillators

- Hydrogen ions in canal-ray tube (Ives & Stilwell) 1939
- Mössbauer experiments with centrifuges in 1960th
- Mössbauer experiments in tower in 1960th
- Cesium clocks in airplanes (Hafele & Keating) 1971
- Hydrogen maser to 10 000 km, Scout D (Vessot) 1976
- GPS satellite system 1980 –
- TAI, International Atomic Time laboratories
- Lunar Laser Ranging, annual perturbations

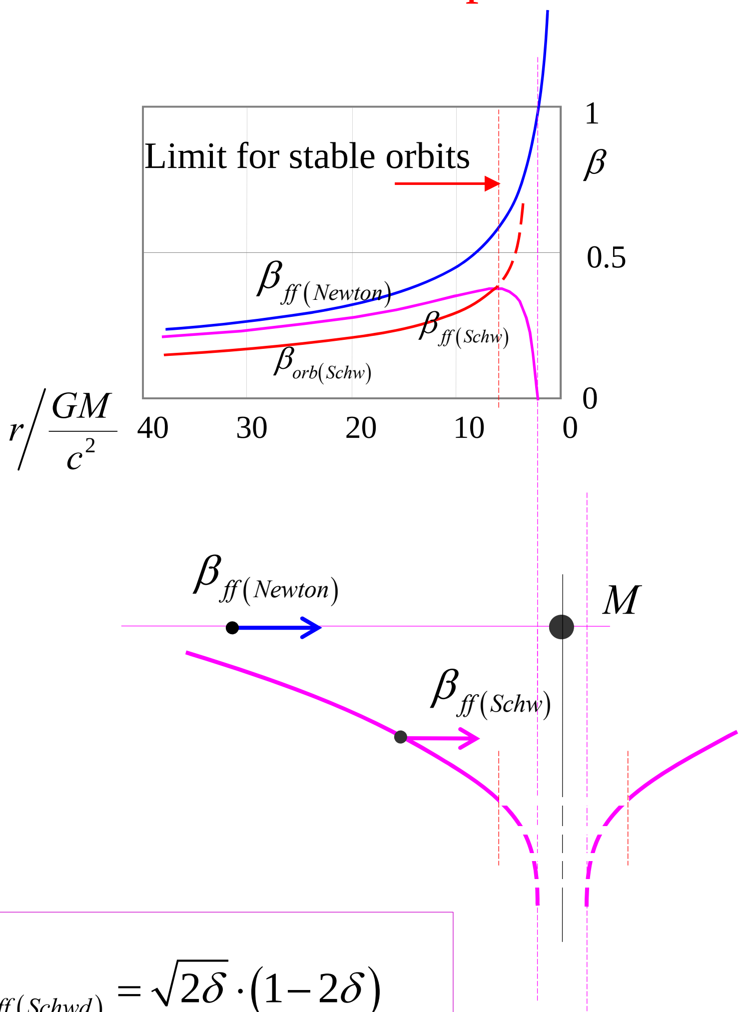
Properties of locally tilted space

Basis of celestial mechanics in GR space and in DU space:

- the velocities of orbital motion and free fall
- perihelion advance
- orbital periods in the vicinity of black holes

Shapiro delay, bending of light near mass centers

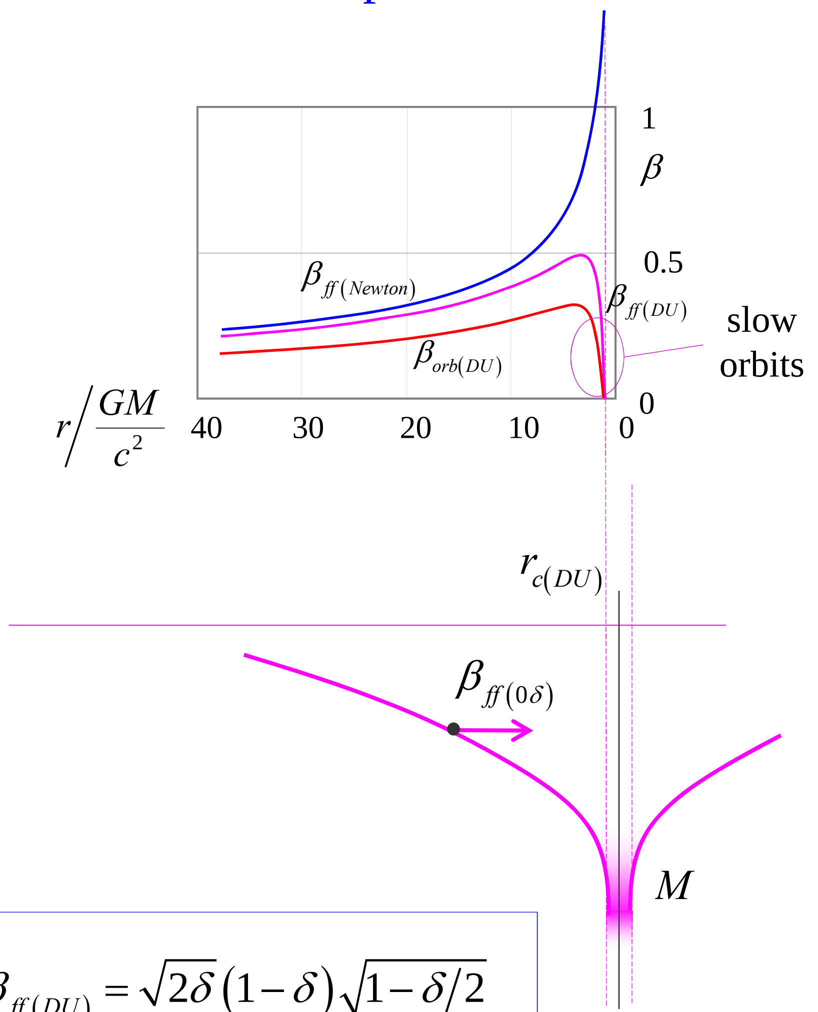
Free fall and orbital velocity in Schwarzschild space:



$$\beta_{ff(Schwd)} = \sqrt{2\delta}\cdot(1-2\delta)$$

$$\beta_{orb(Schwd)} = \sqrt{\delta}\,\frac{1-2\delta}{\sqrt{1-3\delta}}$$

Free fall and orbital velocity in DU space:

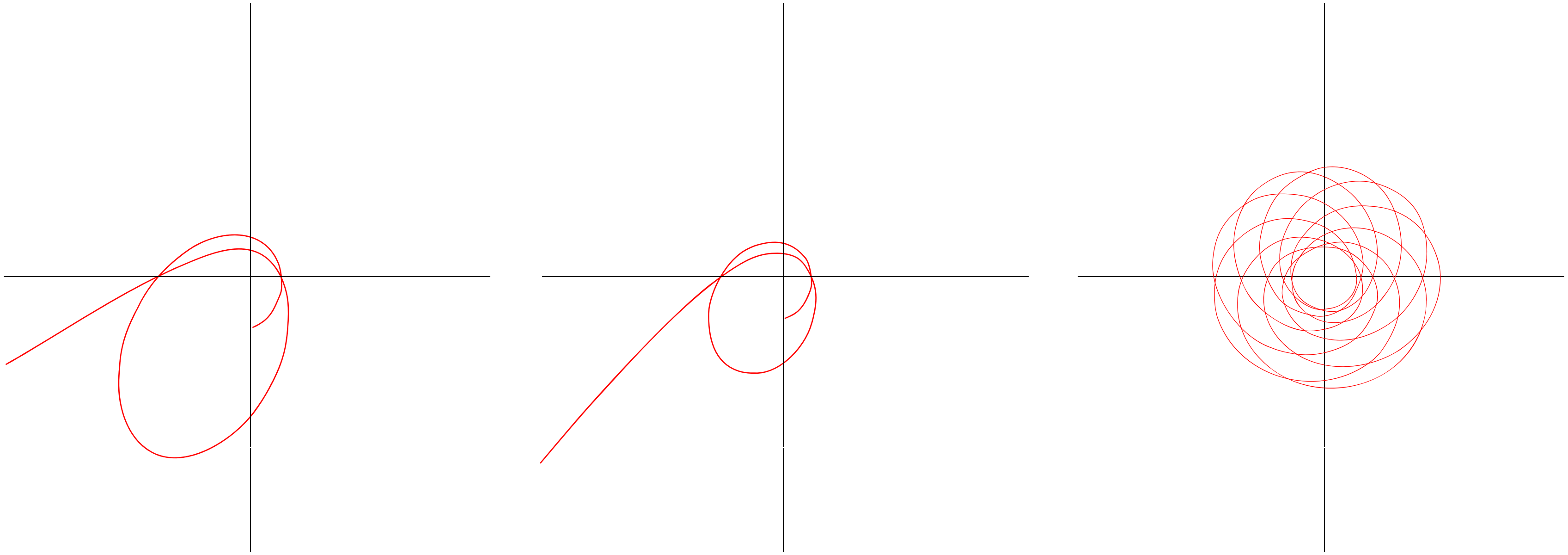


$$\beta_{ff(DU)} = \sqrt{2\delta}\,(1-\delta)\sqrt{1-\delta/2}$$

$$\beta_{orb(DU)} = \sqrt{\delta}\sqrt{(1-\delta)^3}$$

Development of elliptic orbit in GR and DU

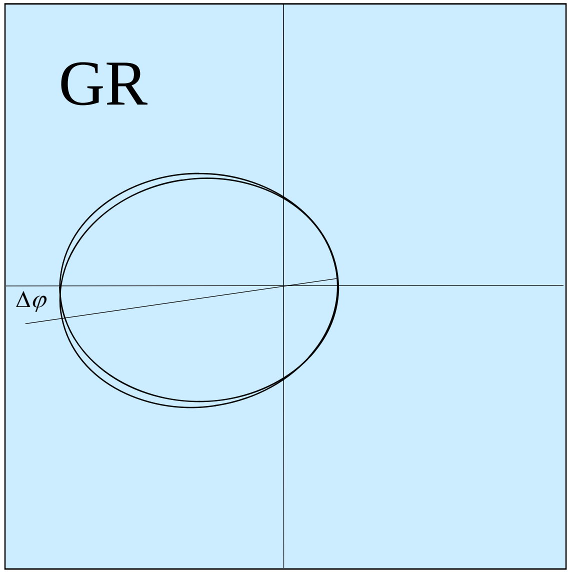
GR, Berry | GR, Weber | Dynamic Universe

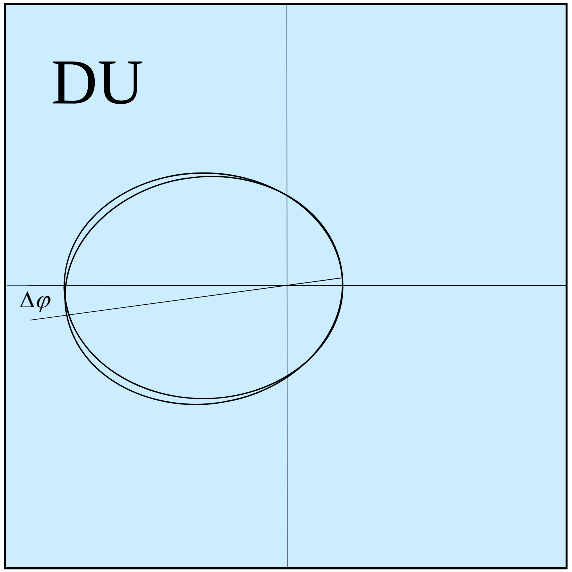


Gravitational factor $r/r_c = 20$

Eccentricity $e = 0.5$

Development of elliptic orbit in GR and DU





Equation (5.37) in J. Weber's book:

$$r=\frac{a\left(1-e^2\right)}{\left\{1+e\sin\varphi-\frac{GM}{c^2a\left(1-e^2\right)}\left[e\left(3\varphi-e\cos\varphi\right)\cos\varphi+3+e^2\right]\right\}}$$

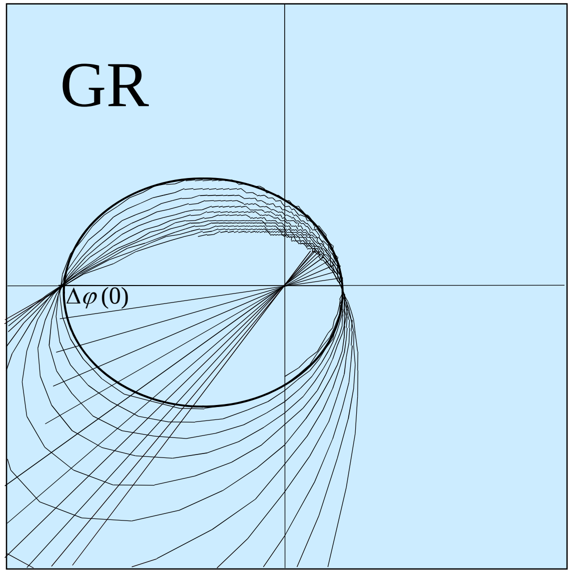
The increase of the orbital radius and the perturbation of the elliptic shape are due to term 3φ in the nominator

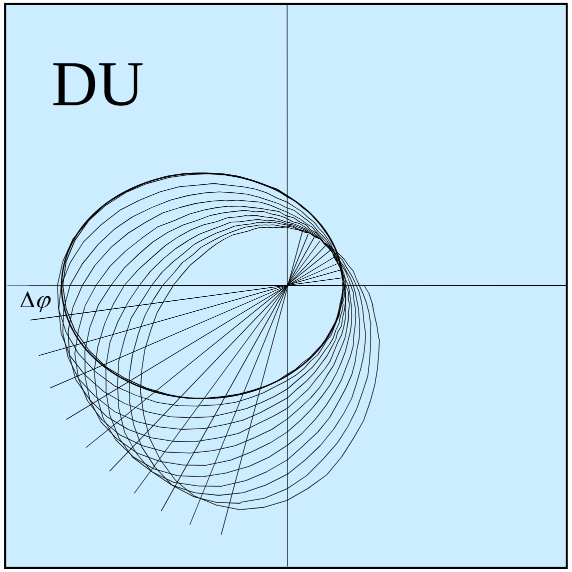
DU equation for elliptic orbits:

$$r_{0\delta}=\frac{a_{0\delta}\left(1-e^2\right)}{1+e\cos\left(\varphi-\Delta\psi_{0\delta}\right)}+\frac{6er_c\left[1-\cos\left(\varphi-\Delta\psi_{0\delta}\right)\right]}{\left(1-e^2\right)}$$

Development of elliptic orbit in GR and DU

Rotation of Mercury perihelion direction by $\Delta\varphi = 45°$ occurs in about 0.5 million years





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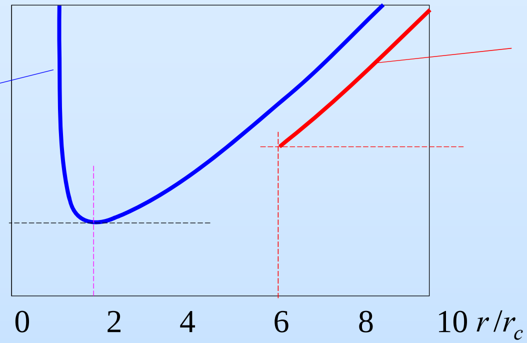
DU equation for elliptic orbits:

$$r_{0\delta} = \frac{a_{0\delta}\left(1-e^2\right)}{1+e\cos\left(\varphi - \Delta\psi_{0\delta}\right)} + \frac{6er_c\left[1-\cos\left(\varphi-\Delta\psi_{0\delta}\right)\right]}{\left(1-e^2\right)}$$

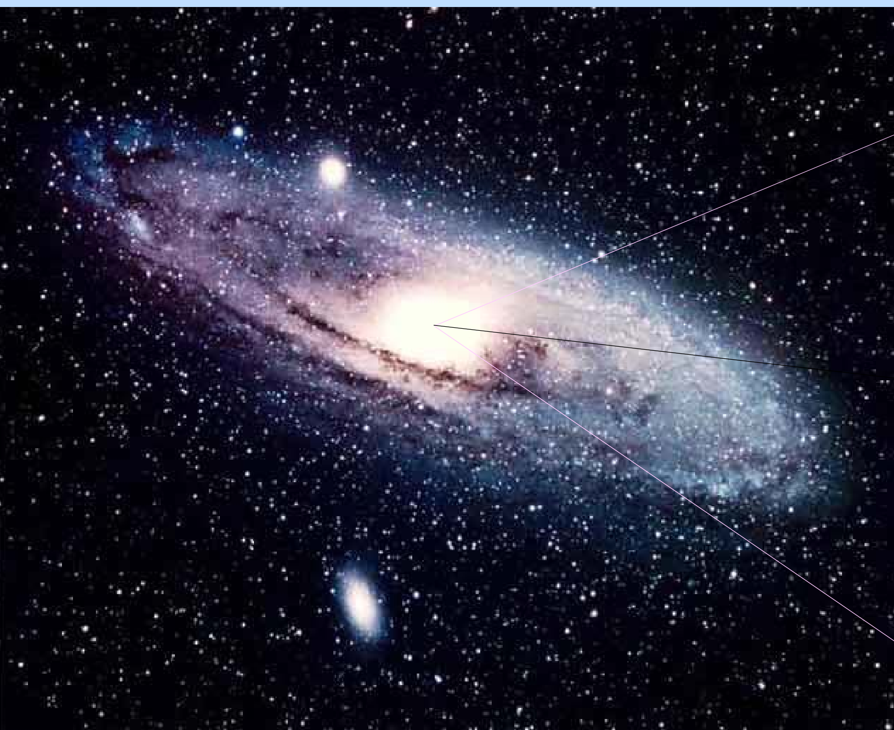
Orbital period near black hole

DU: $$P = \frac{2\pi r/c}{\sqrt{\frac{r_{c(DU)}}{r}\left(1-\frac{r_{c(DU)}}{r}\right)^3}}$$

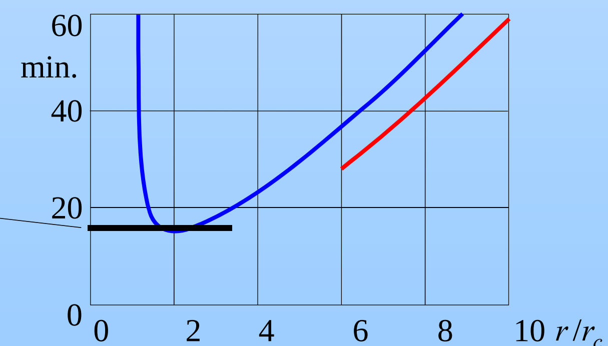


$$P = \frac{2\pi r/c}{\sqrt{\frac{r_{c(DU)}}{r}}}$$ Schwarzschild

http://www.youtube.com/watch?v=k7xl_zjz0o8&NR=1



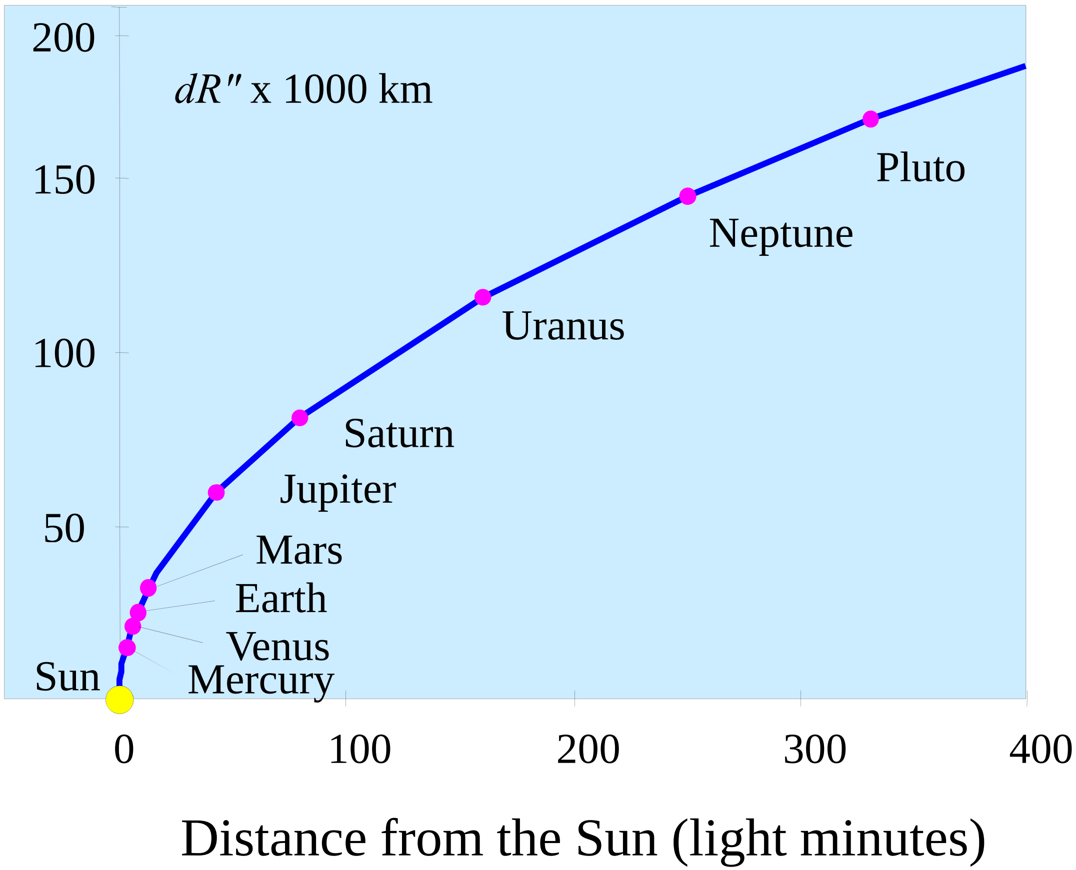
Sgr A*: $M \cong 3.7$ million solar masses
$r_{c(\mathrm{DU})} \cong 5.3$ million kilometers



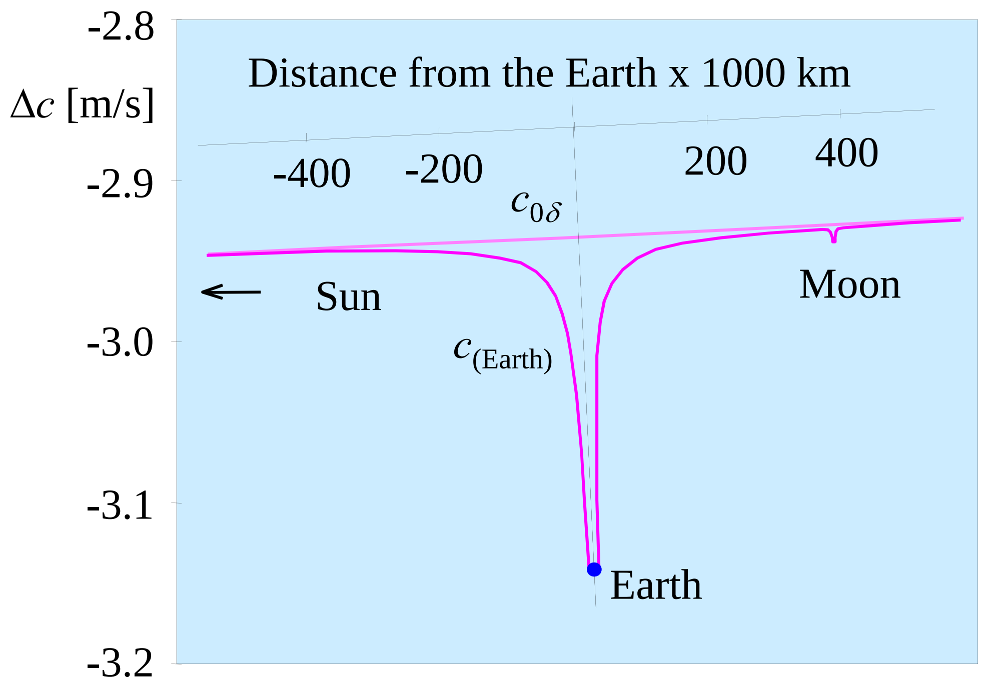
Observed 16.8 min rotation period at Milky Way Center, Sgr A*
[R. Genzel, *et al*., Nature 425, 934 (2003)]

Geometry of local dents, Shapiro delay, bending of light

The 4D depth profile of the planetary system

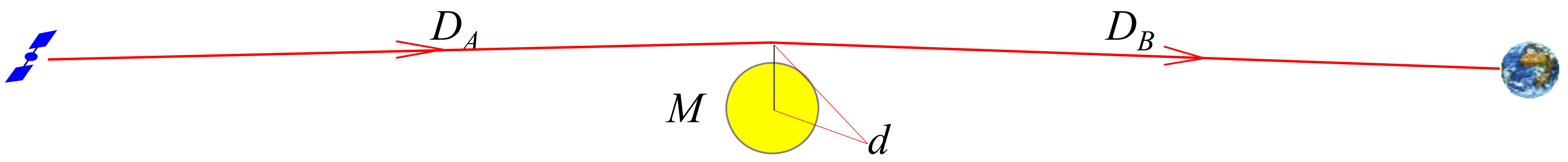


The velocity of light in the vicinity of the Earth



$$c = c_{0\delta}\left(1-\delta_e\right) = c_{0\delta}\left(1-\frac{GM_e}{r_{0\delta}c_0c_{0\delta}}\right)$$

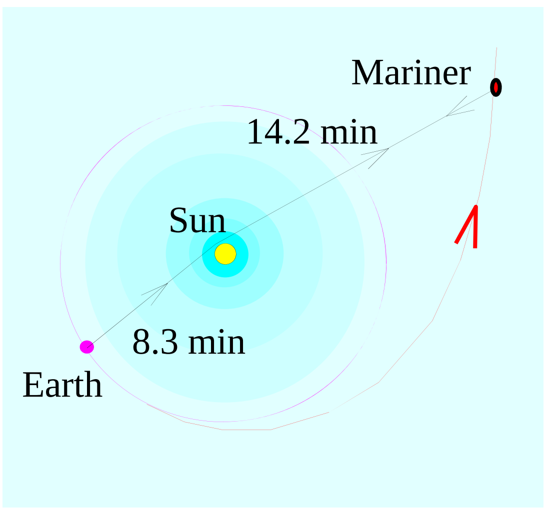
Shapiro delay of radio signal

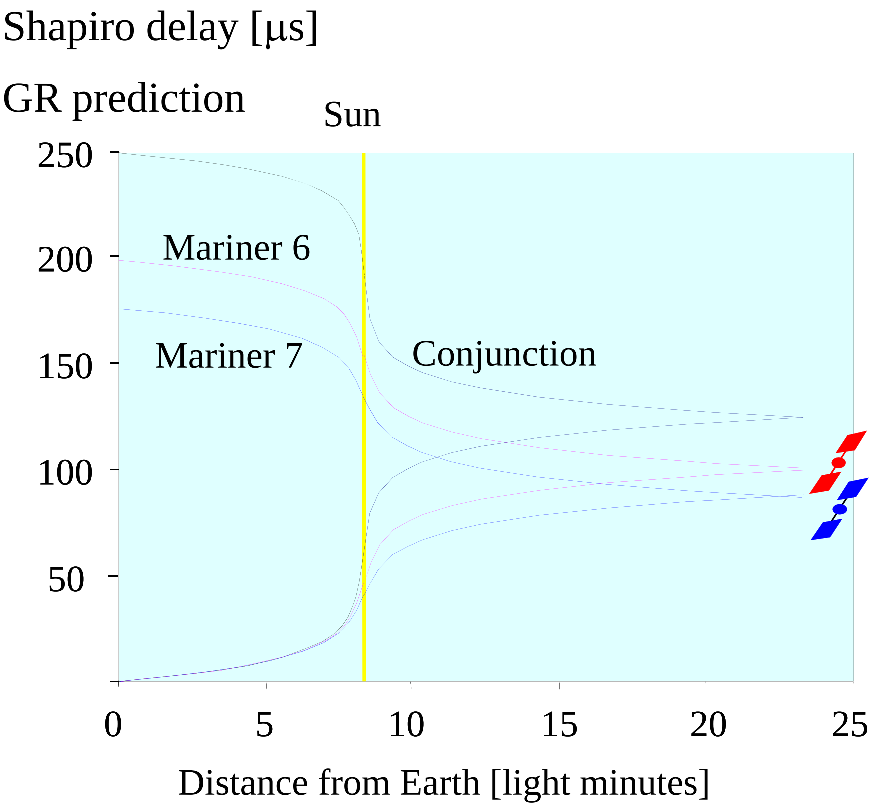


GR: $$\Delta T_{D_A,D_B} = \frac{2GM}{c^3}\ln\left[\frac{4D_A D_B}{d^2}\right]$$

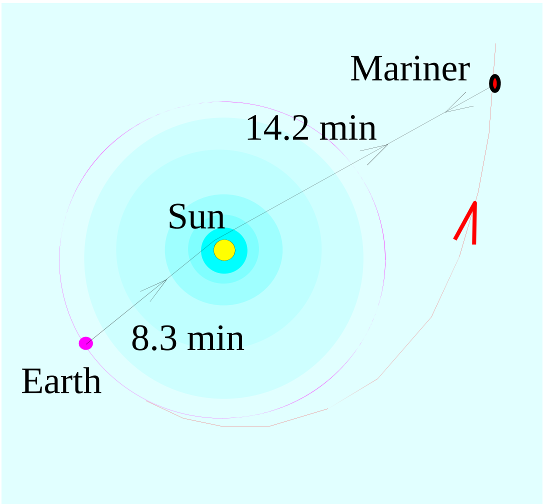
DU: $$\Delta T_{D_A,D_B} = \frac{2GM}{c^3}\left\{\ln\left[\frac{4D_A D_B}{d^2}\right]-1\right\}$$

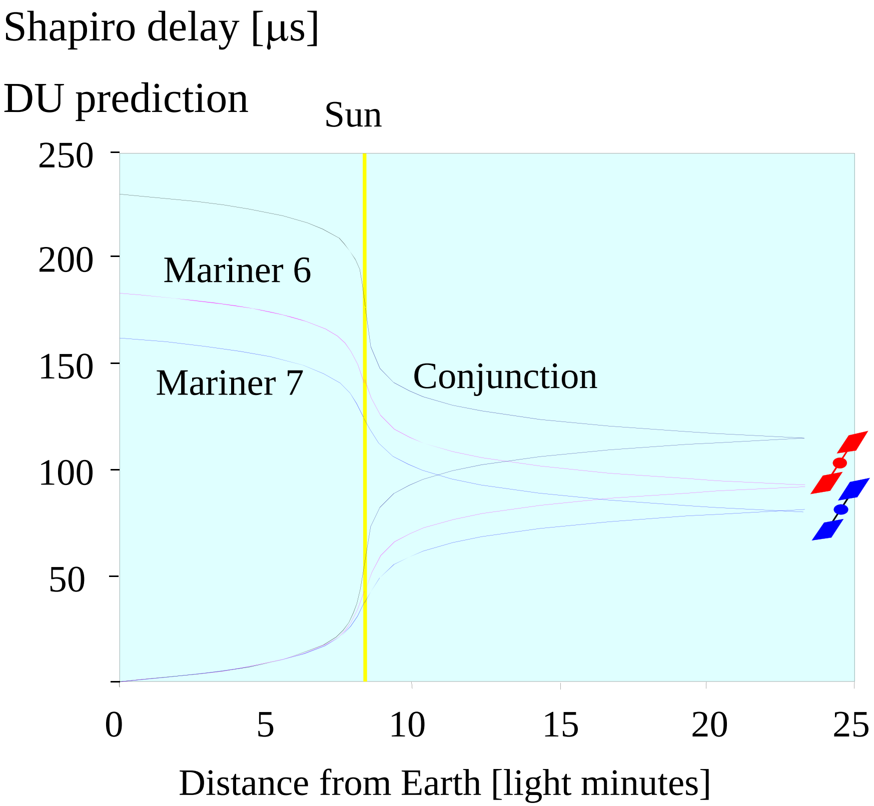
Mariner 6 and 7 experiments



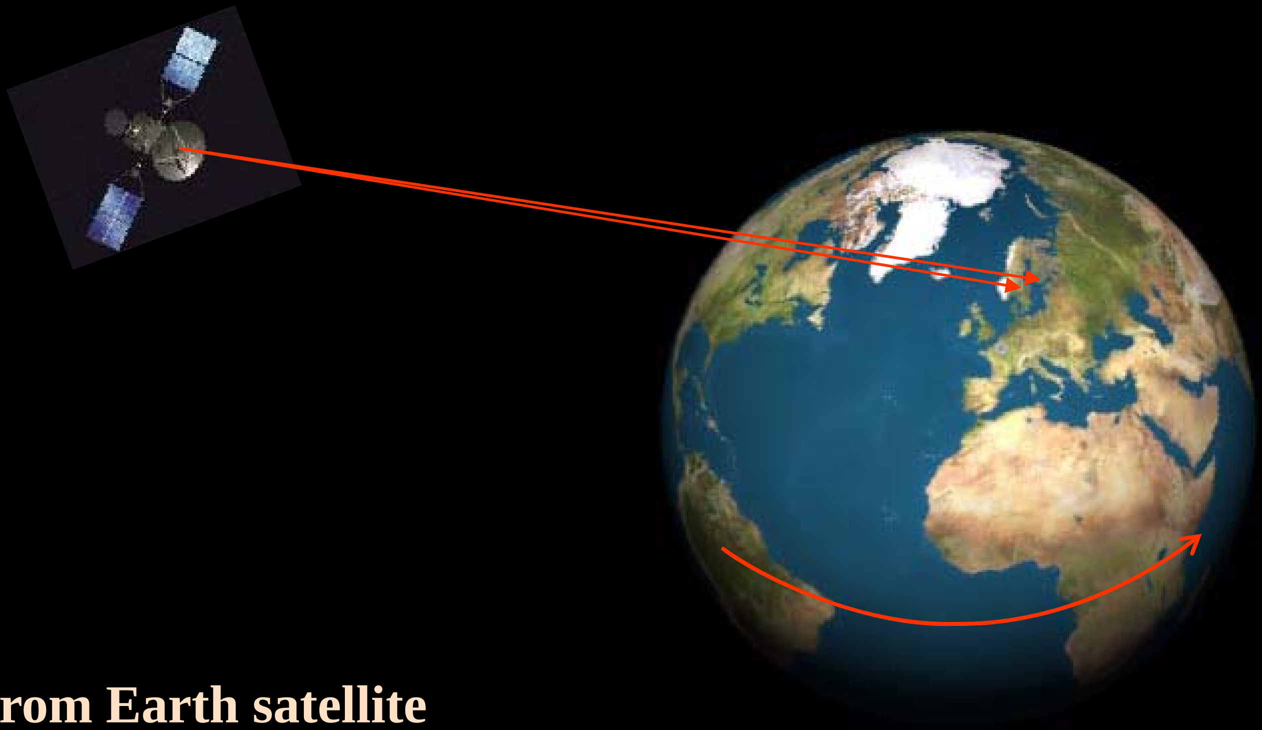


Mariner 6 and 7 experiments





Observation of electromagnetic radiation



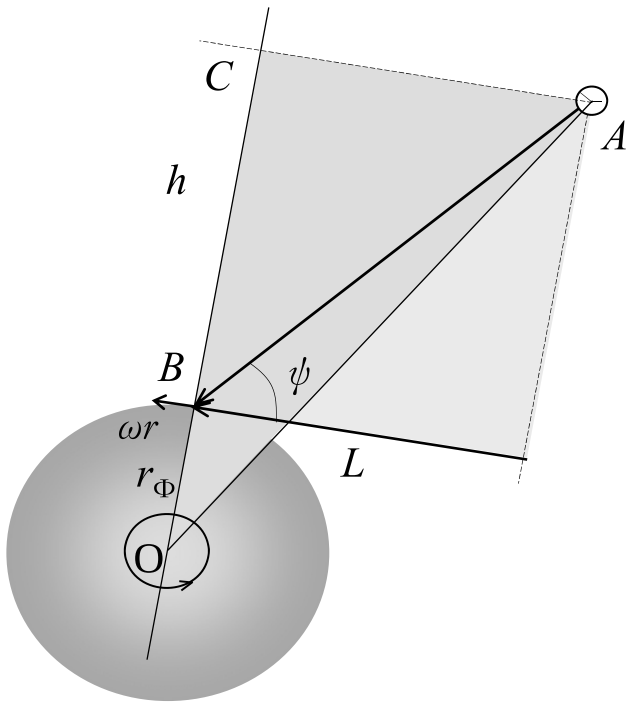
Signal transmission from Earth satellite

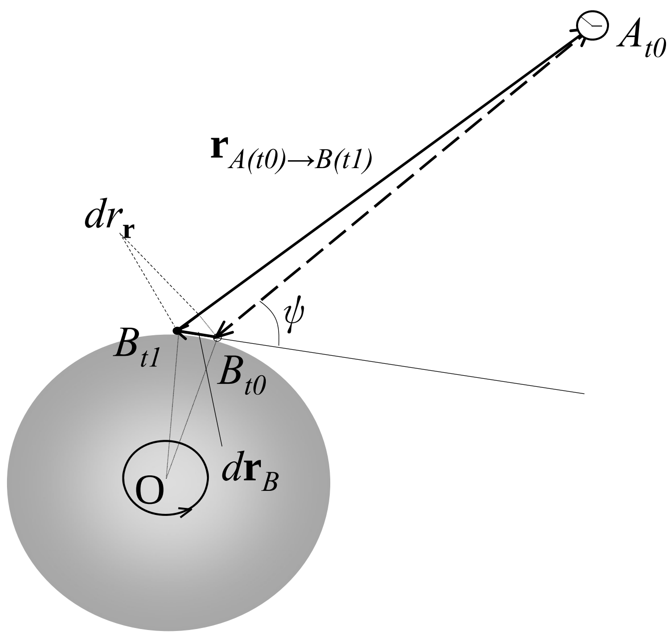
$$T = \frac{L}{c} = \frac{L_0 + \Delta L}{c} = \frac{L_0}{c} + \frac{v_L T}{c}$$

Sagnac delay

$$T = \frac{T_0}{1 - v_L / c}$$

Sagnac effect in satellite communication

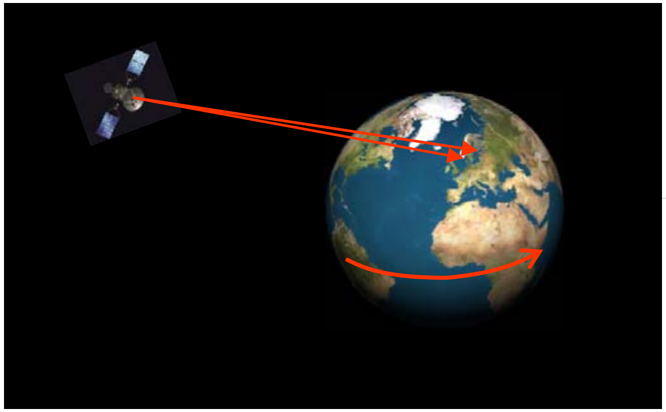


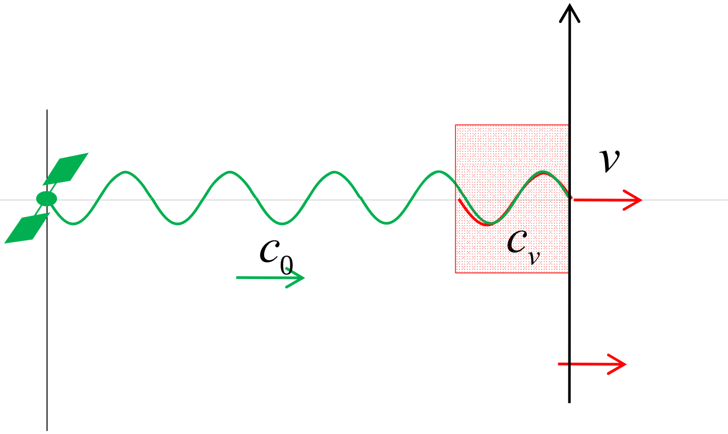


$$\Delta T_{\omega(Earth)} = \frac{2\omega A_{ABO}}{c^2}$$

$$T_{AB} = \frac{\mathbf{r}_{AB(t0)} \cdot \hat{\mathbf{r}}_{AB}}{c\left(1-\beta_{B(\mathbf{r})}\right)}$$

Observation of radiation in a moving frame





Sagnac delayed signal

$$T_{Sagnac} = \frac{T_0}{1 - v_L/c}$$

$$L_{Sagnac} = \frac{L_0}{1 - v_L/c}$$

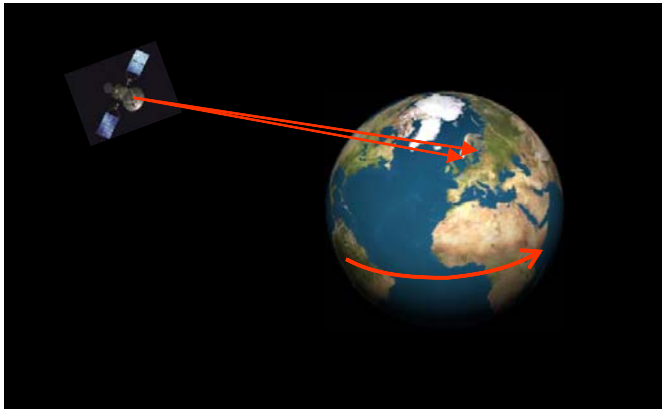
Doppler shifted radiation

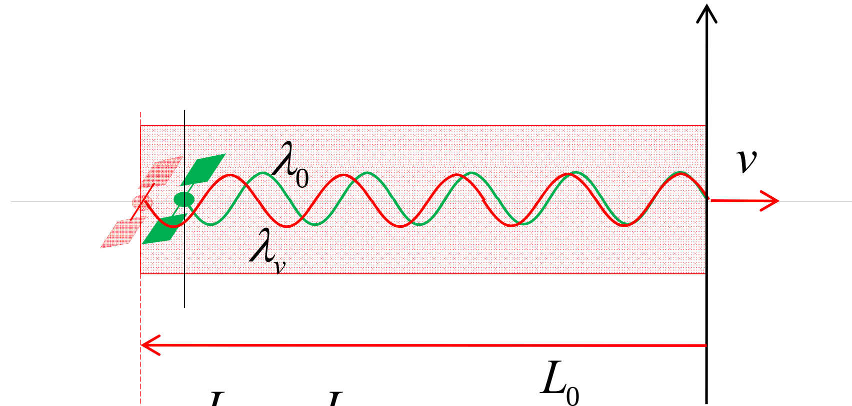
$$T_v = T_{Doppler} = \frac{T_0}{1 - v/c} = \frac{1}{f_v}$$

$$\lambda_v = \lambda_{Doppler} = \frac{L_0}{1 - v/c}$$

Phase velocity in moving frame $c_v = f_v \cdot \lambda_v = f_0 \cdot \lambda_0 = c_0$

Observation of radiation in a moving frame





$$L_{opt} = L_{Sagnac} = \frac{L_0}{1 - v_L/c}$$

Momentum in propagation frame

$$\mathbf{p}_0 = \frac{h_0}{\lambda_0}\mathbf{c}_0$$

Momentum in observer's frame

$$\mathbf{p}_v = \frac{h_0}{\lambda_v}\mathbf{c}_v = \frac{h_0}{\lambda_0}\left(1 - \frac{v}{c}\right)\mathbf{c}_v$$

Phase velocity in moving frame

$$c_v = f_v \cdot \lambda_v = f_0 \cdot \lambda_0 = c_0$$

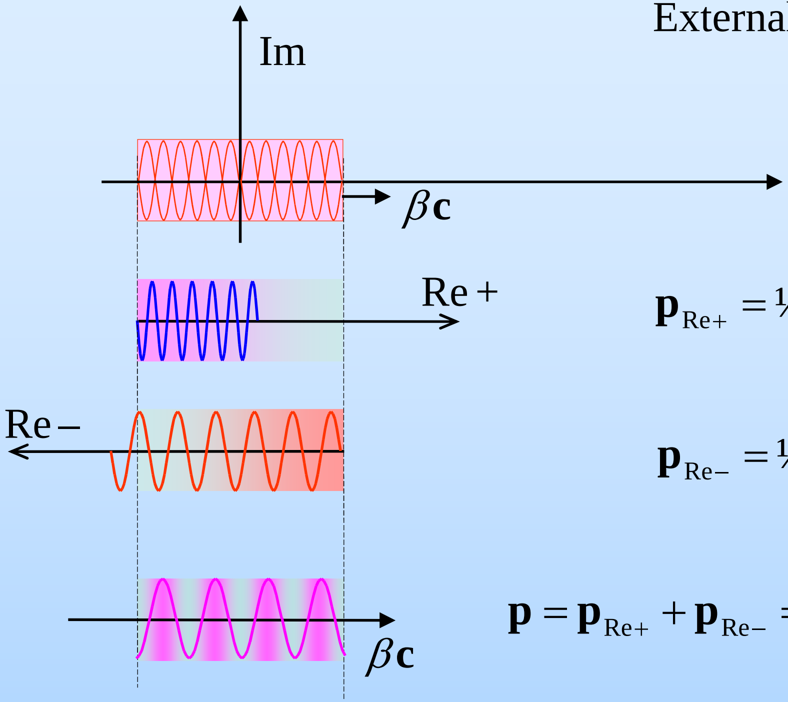
Mass object as Compton resonator

Internal (rest) momentum

$$\mathbf{p}_{I(\mathrm{Re})+} = ½ \cdot \frac{h_0}{\lambda_C} \cdot \mathbf{c}_{\mathrm{Re}+}$$

$$\mathbf{p}_{I(\mathrm{Re})-} = ½ \cdot \frac{h_0}{\lambda_C} \cdot \mathbf{c}_{\mathrm{Re}-}$$

$$\lambda_C = \frac{h_0}{m_0\sqrt{1-\beta^2}}$$



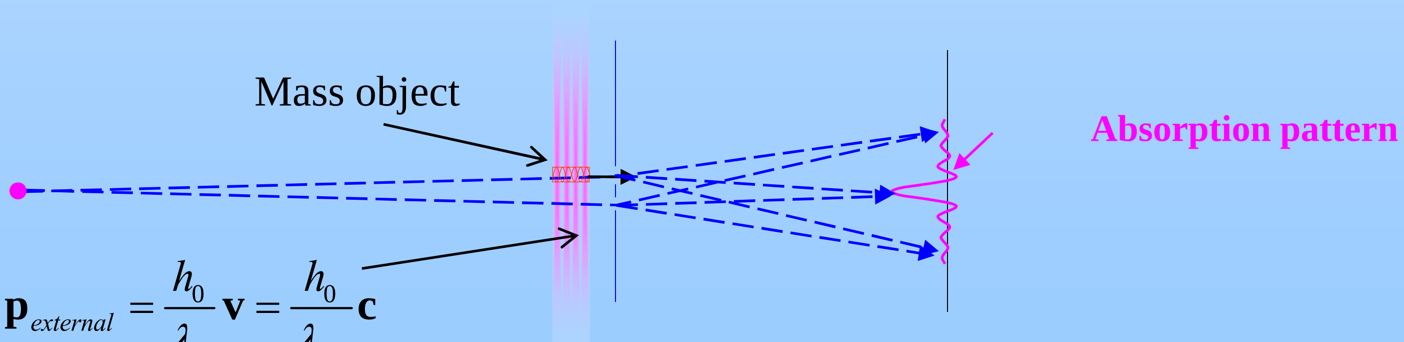
External momentum

$$\mathbf{p}_{\mathrm{Re}+} = ½ \frac{h_0\sqrt{1-\beta^2}}{\lambda_0\left(1+\beta\right)}\mathbf{c}_{\mathrm{Re}+}$$

$$\mathbf{p}_{\mathrm{Re}-} = ½ \frac{h_0\sqrt{1-\beta^2}}{\lambda_0\left(1-\beta\right)}\mathbf{c}_{\mathrm{Re}-}$$

$$\mathbf{p} = \mathbf{p}_{\mathrm{Re}+} + \mathbf{p}_{\mathrm{Re}-} = \frac{h_0}{\lambda_0\sqrt{1-\beta^2}}\beta\,\mathbf{c}_{\mathrm{Re}+} = m_{eff}\,\mathbf{v}$$

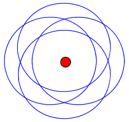
The double slit experiment



$$\mathbf{p}_{external} = \frac{h_0}{\lambda_\beta}\mathbf{v} = \frac{h_0}{\lambda_{dB}}\mathbf{c}$$

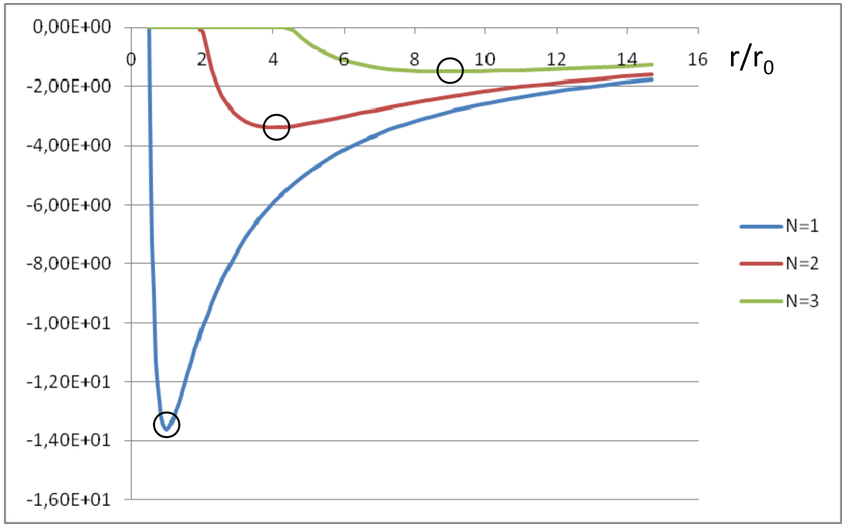
Hydrogen atom:
Electron energy minima as resonant mass wave states

$$p=\frac{h_0}{\lambda}c=\frac{h_0}{2\pi r/n}c=\frac{n\hbar_0}{r}c$$



$$E_{rest}=\frac{h_0}{\lambda_0}\cdot c^2=\hbar_0 k_0\cdot c^2$$

$$E_{Coulomb}=-\frac{Ze^2\mu_0}{2\pi r}c^2=-\frac{Z\alpha\hbar_0}{r}c^2$$



$$E_{tot}=c\sqrt{(mc)^2+p^2}-mc^2-\frac{Z\alpha\hbar_0}{r}c^2$$

Kinetic energy — Coulomb energy

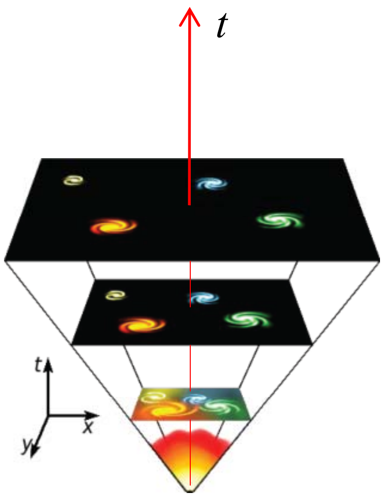
$$E_{(Z,n)}=E_{rest}\left[\sqrt{1+\left(\frac{n}{k_0 r}\right)^2}-1-\frac{Z\alpha}{k_0 r}\right]$$

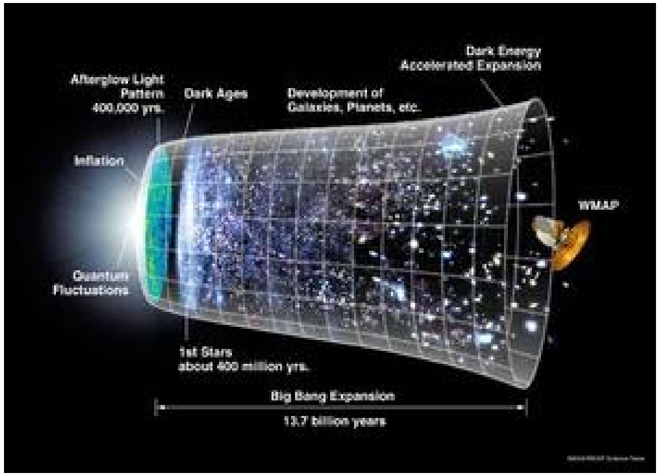
$$E_{tot(\min)}=-\left[1-\sqrt{1-\left(\frac{Z\alpha}{n}\right)^2}\right]mc^2\approx-\left(\frac{Z}{n}\right)^2\frac{\alpha^2}{2}mc^2=\left(\frac{Z}{n}\right)^2 R_\infty hc$$

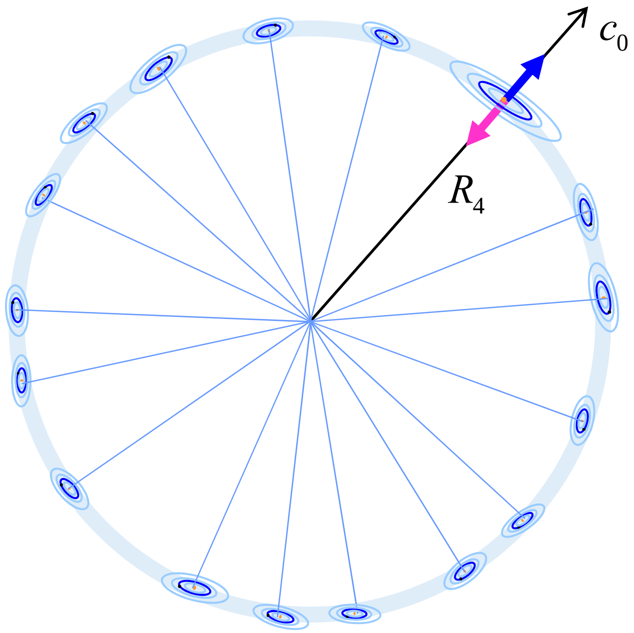
Cosmological properties of spherically closed space

GR / FLRW space and DU space

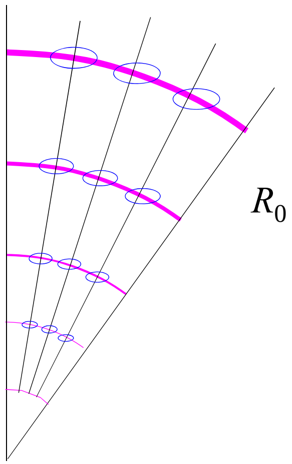
FLRW cosmology	Dynamic Universe

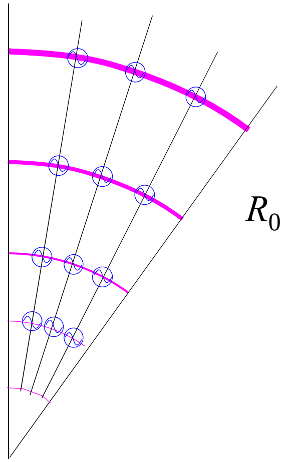


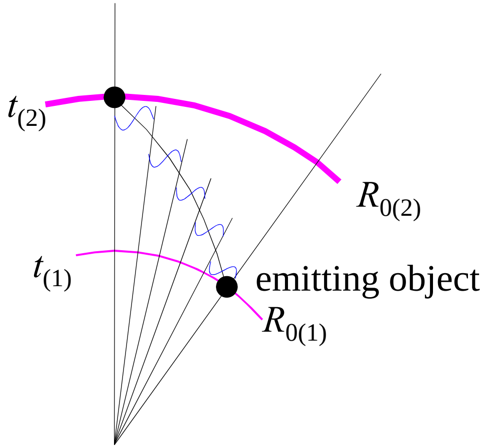




Expanding and non-expanding objects in DU-space.







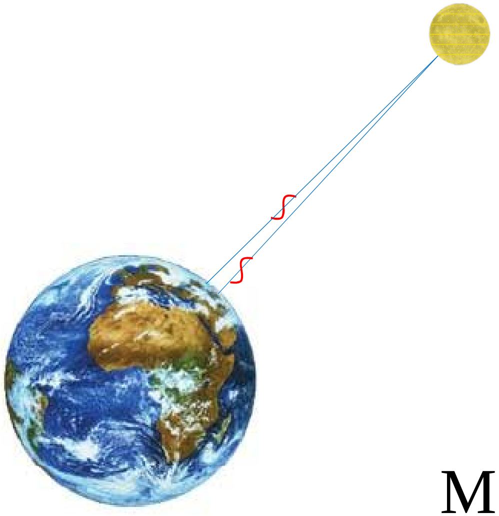
Gravitational systems expand with the expansion of space

Electromagnetic objects, like atoms, conserve their dimensions

The wavelength of electromagnetic radiation propagating in space increases in direct proportion to the expansion

Annual increase of the Earth to Moon distance

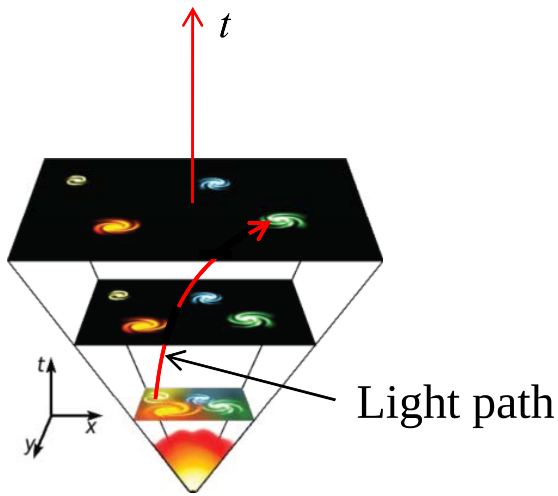
Lunar Laser Ranging

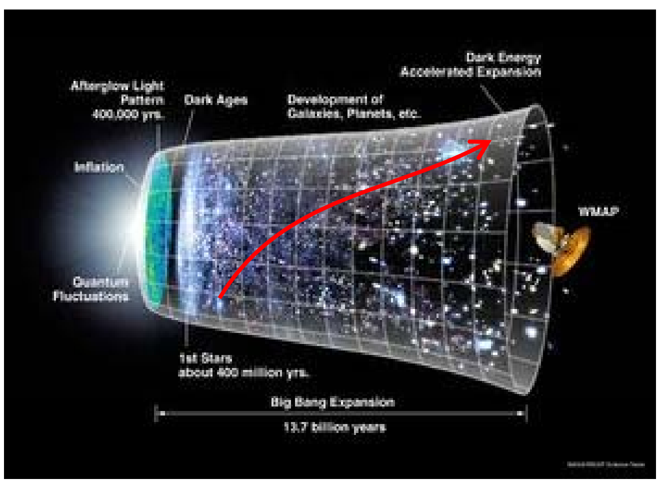


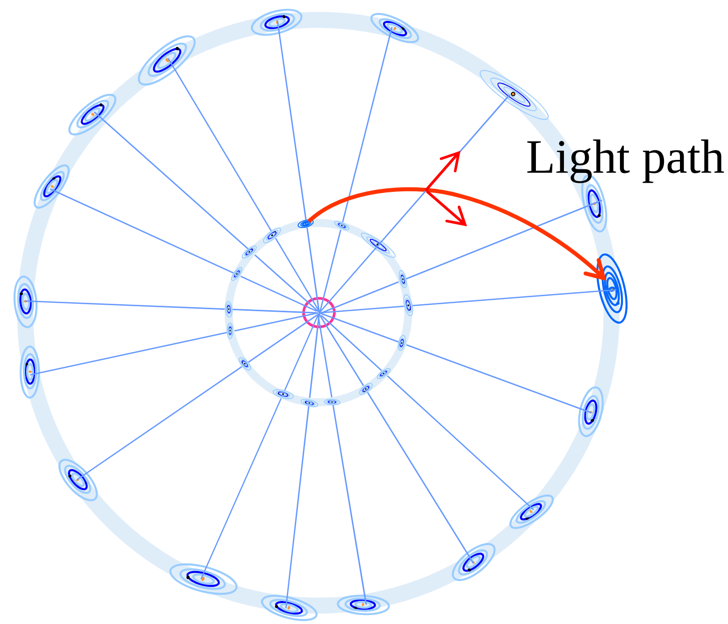
	GR	DU
Measured	38 mm	38 mm
Expansion of space	0	28 mm
Tidal interactions	38 mm	10 mm

GR / FLRW space and DU space

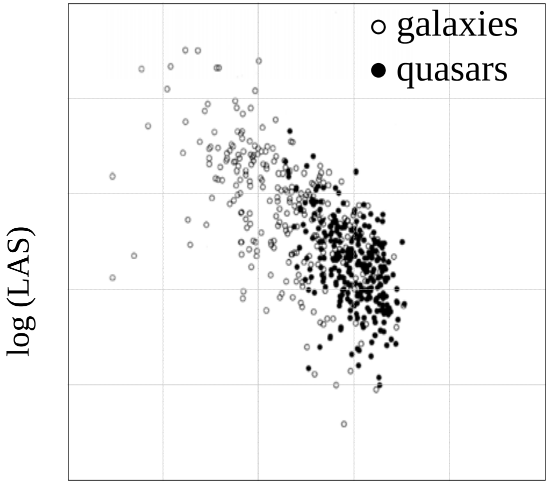
FLRW cosmology	Dynamic Universe

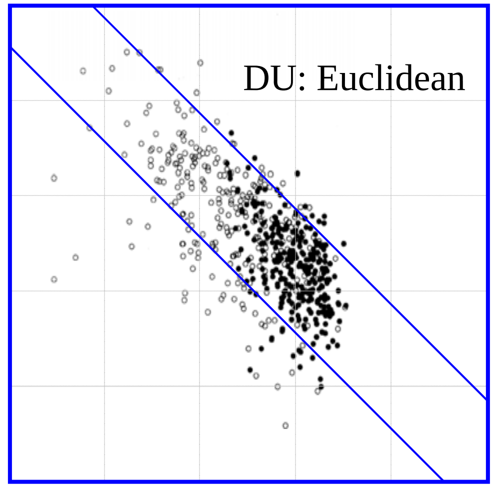






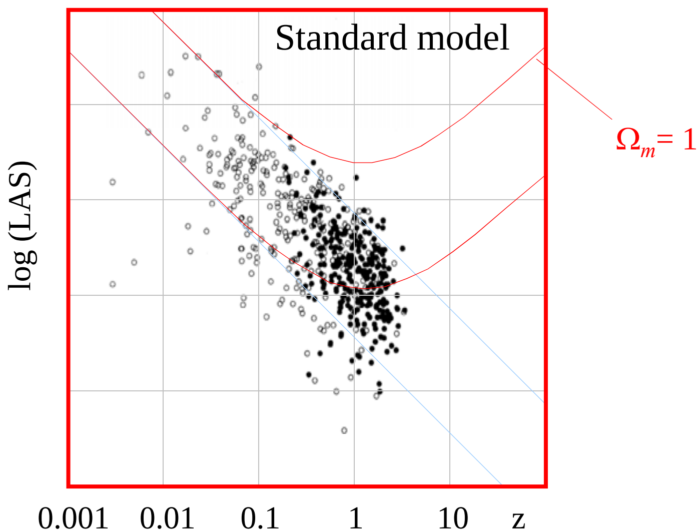
Angular size of galaxies and quasars





Dynamic Universe:

Euclidean $$\theta = \frac{r_0}{R_4}\frac{1}{z}$$



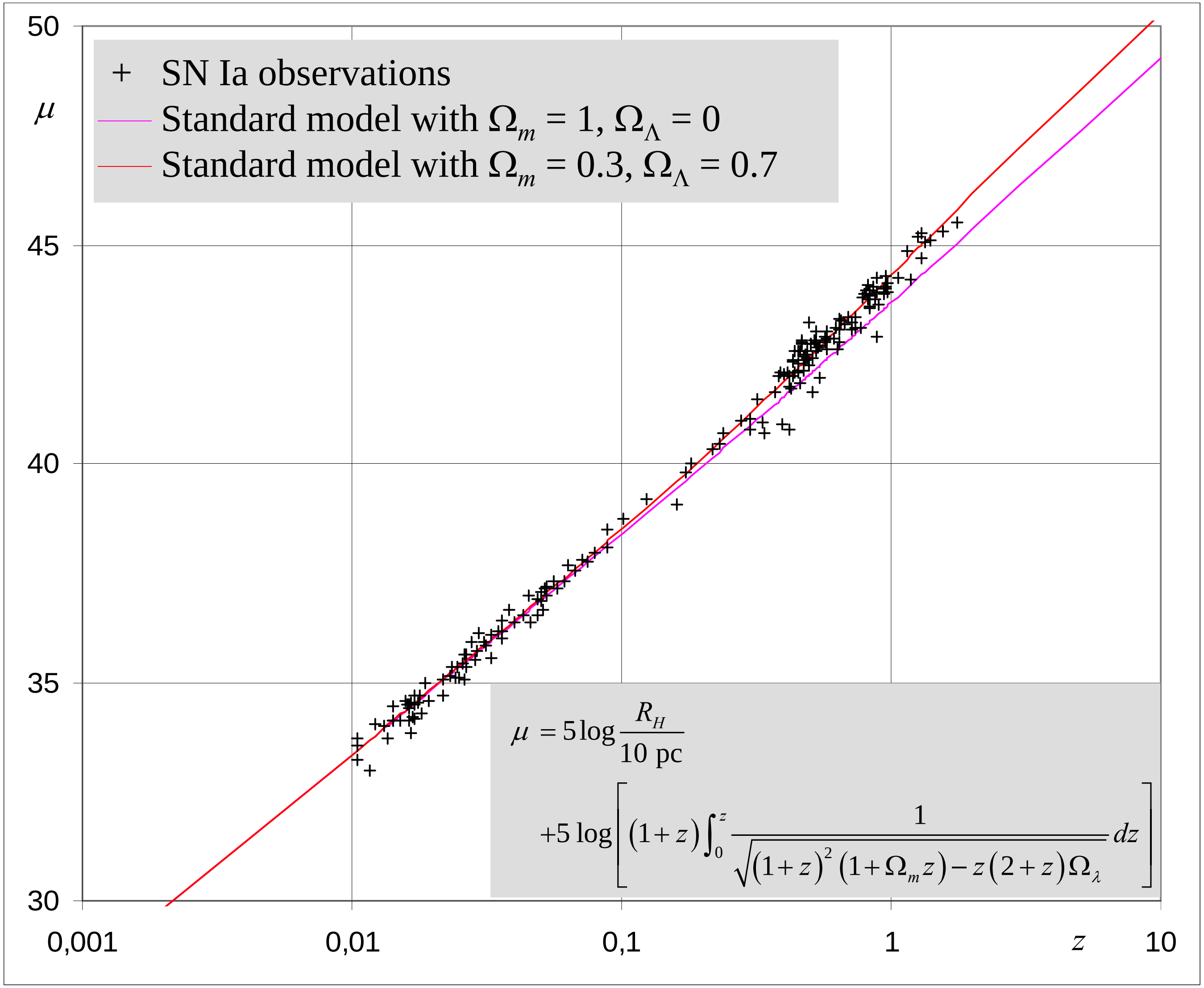
FLRW cosmology

$$\theta = \frac{r_0}{R_H} = (1+z) \Bigg/ \int_0^z \frac{1}{\sqrt{(1+z)^2(1+\Omega_m z) - z(2+z)\Omega_\Lambda}}\,dz$$

Collection of data: K. Nilsson *et al.*, Astrophys. J., **413**, 453 (1993)

Virtual image Distances

Magnitude versus redshift: Supernova observations

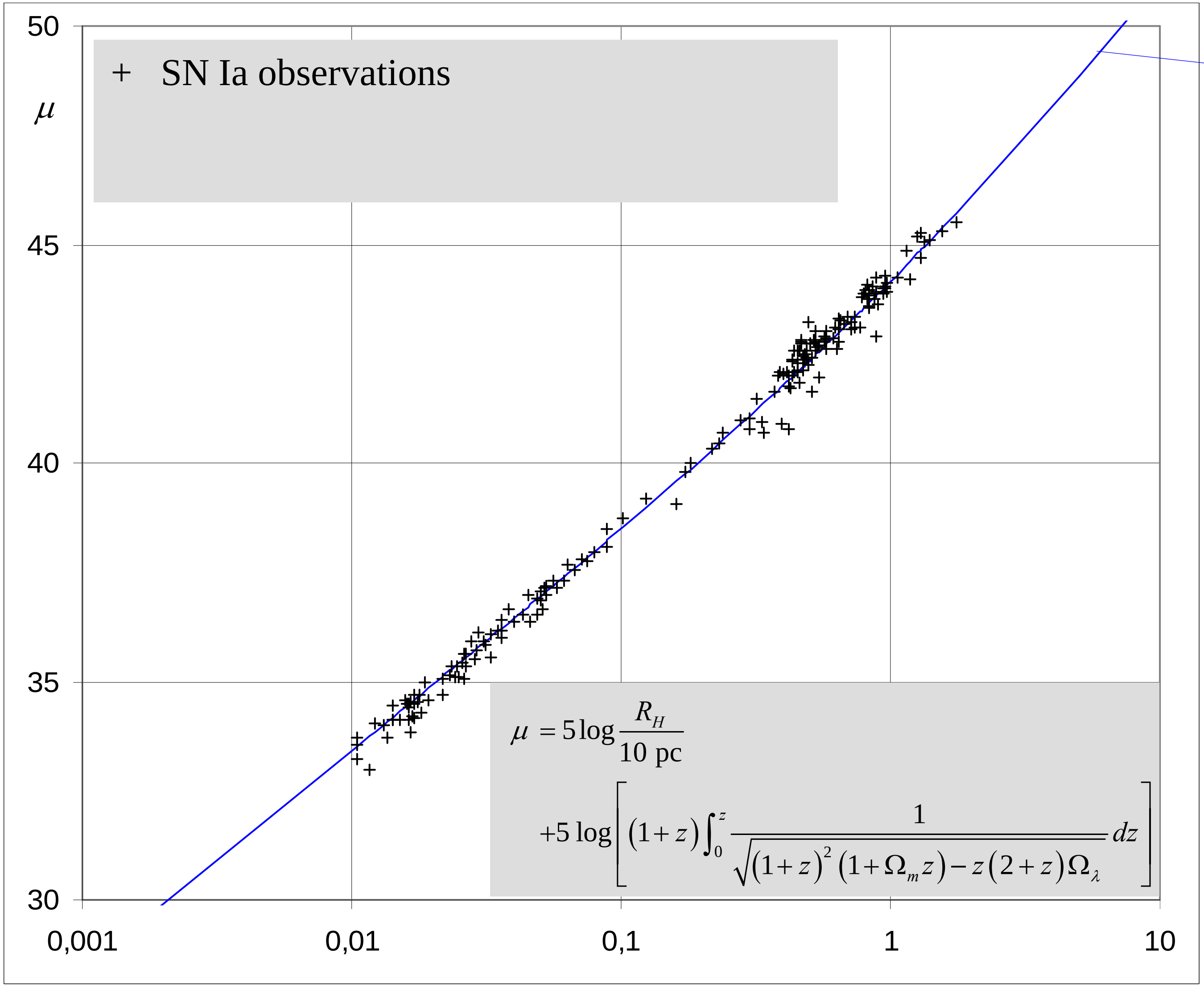


$$\mu = 5 \log \frac{R_H}{10\ \mathrm{pc}} + 5 \log \left[(1+z) \int_0^z \frac{1}{\sqrt{(1+z)^2 (1+\Omega_m z) - z(2+z)\Omega_\lambda}} dz \right]$$

Data:
A. G. Riess, *et al.*, Astrophys. J., 607, 665 (2004)

Suggested correction:
$\Omega_m = 0.3$
$\Omega_\Lambda = 0.7$ (dark energy)

Magnitude versus redshift: Supernova observations



DU space

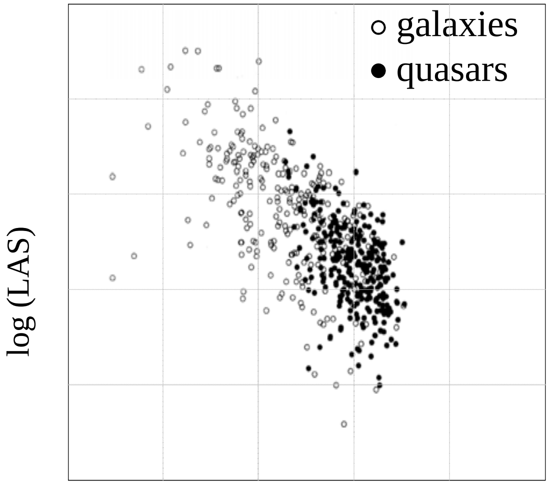
$$\mu = 5\log\frac{R_4}{10\text{ pc}} + 2.5\log\left(\frac{z^2}{1+z}\right)$$

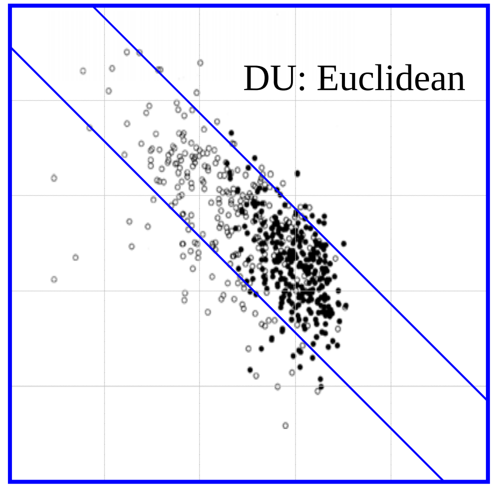
Data:
A. G. Riess, *et al.*,
Astrophys. J., 607, 665
(2004)

Magnitude versus redshift

How does the dark energy hypothesis change
the angular diameter prediction?

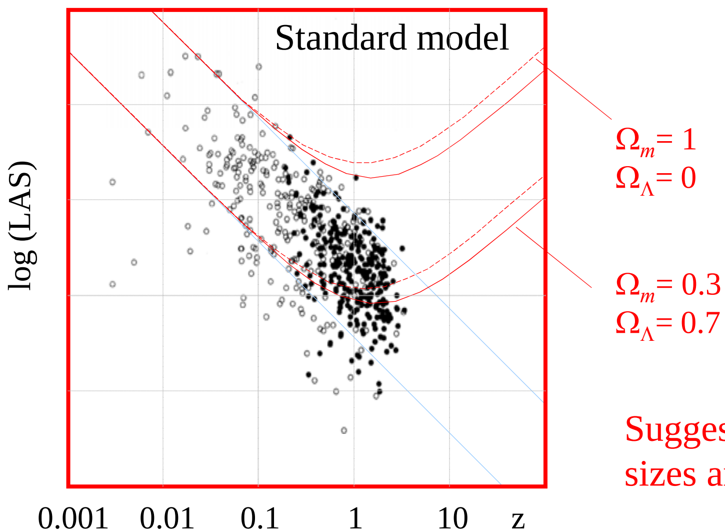
Angular size of galaxies and quasars





Dynamic Universe:

Euclidean $$\theta = \frac{r_0}{R_4}\frac{1}{z}$$



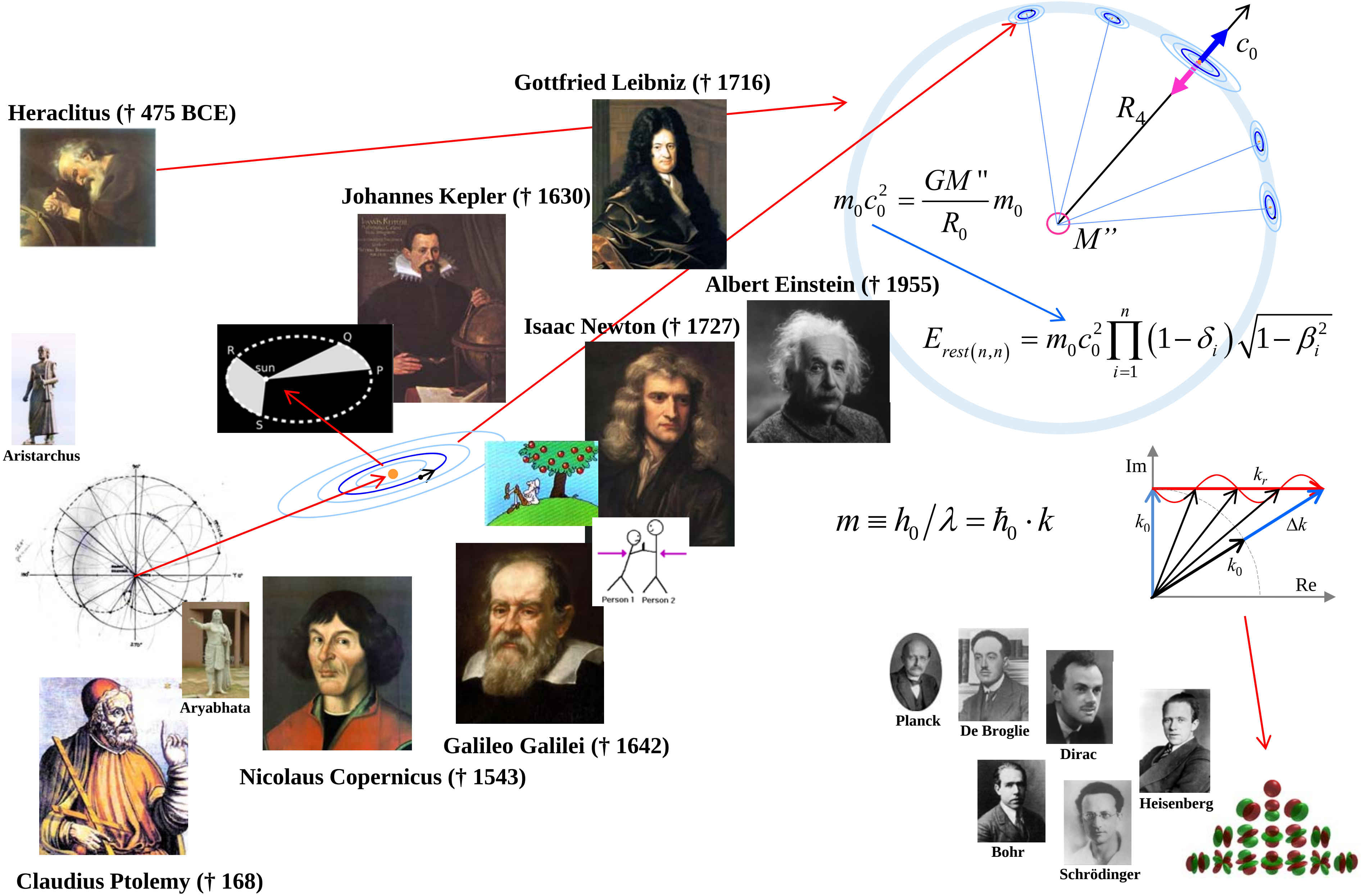
FLRW cosmology

$$\theta = \frac{r_0}{R_H} = (1+z) \Big/ \int_0^z \frac{1}{\sqrt{(1+z)^2(1+\Omega_m z) - z(2+z)\Omega_\Lambda}}\,dz$$

Suggested explanation: high z galaxies are young;
sizes are still developing (not supported by spectral data!)

Collection of data: K. Nilsson *et al.*, Astrophys. J., **413**, 453 (1993)

From Earth centered to 4-sphere centered universe



The Dynamic Universe

- Offers a holistic – from whole to local approach for describing physical reality
- Relies on a few fundamental postulate
- Covers a wide range phenomena - from microstructures to cosmological dimensions – in a unified formalism
- Produces accurate predictions with straightforward mathematics and clear logic
- Produces a comprehensive picture of physical reality

Development paths of physics and astronomy