

Galactic Evolution

without Dark Matter

Version-2021.06

Unresolved mystery of the **galaxy rotation curve**:

- The rotation velocity of a galactic disc is same at any radial distances.
- Unknown Dark Matter is expected, but not observed.

Uniform circular motion:

$$m\omega^2 r - K \frac{Mm}{r^2} = 0, \quad v^2 r = KM$$

The centrifugal force and the centripetal force balance.

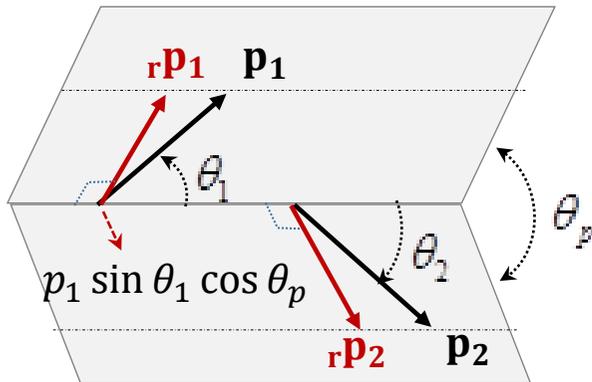
v^2 is inversely proportional to the radius r .

Fundamental force may control the evolution of galaxies.

< Fundamental force (by the Energy Circulation Theory) >

Fundamental force:

- Works based on momentums.
- $r\mathbf{p}$: orthogonal component of a momentum to the distance direction
- Positive force is repulsive, and negative one is attractive.
- Electric and magnetic forces are presentations of the fundamental force.

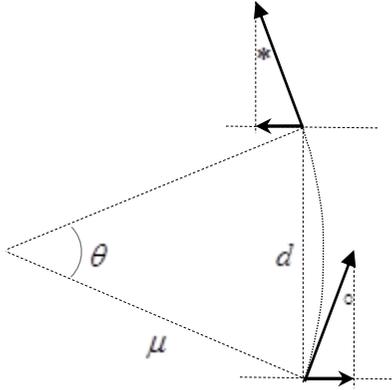


$$F = K_f \frac{\mathbf{r}\mathbf{p}_1 \cdot \mathbf{r}\mathbf{p}_2}{d^2} = K_f \frac{p_1 p_2}{d^2} \cos \theta_p \sin \theta_1 \sin \theta_2$$

K_f : Fundamental force constant

Intra-circulation force:

$\Delta p_0, \Delta p_\theta$: local minute momentums on the circumference at 0 and θ .



$$\circ: +\theta/2, \quad *: -\theta/2$$

$$d = 2\mu \sin \frac{\theta}{2}$$

$$F = K_f \frac{\Delta p_0 \Delta p_\theta}{d^2} \sin \frac{\theta}{2} \sin \frac{-\theta}{2} = -K_f \frac{\Delta p_0 \Delta p_\theta}{4\mu^2}$$

Sum of local forces on Δp_0 with the whole circumference:

$$cF_{\perp} = -K_f \frac{\Delta p_0}{4\mu^2} \int_0^{2\pi} \Delta p_\theta \sin \frac{\theta}{2} d\theta = -K_f \frac{\Delta p_0}{4\mu^2} \frac{4p}{2\pi} = -K_f \frac{p\Delta p_0}{2\pi\mu^2}$$

Intrinsic energies m and M are moving at $V_c = \mu\omega$.

$$cF_{\perp} = -K_f \frac{p\Delta p_0}{2\pi\mu^2} = -K_f \frac{E\Delta E}{2\pi V_c^2 \mu^2} = -K_f V_c^2 \frac{Mm}{2\pi\mu^2}$$

$$cF_{//} = -K_f \frac{\Delta p_0}{4\mu^2} \int_0^{2\pi} \Delta p_\theta \cos \frac{\theta}{2} d\theta = 0$$

< Effect of the space expansion on the circulating speed >

Movement in 3D in general: $x\mathbf{e}_0$: radius of universe, \mathbf{r} : space vector in 3D

Intrinsic energy E_0 moving at v in \mathbf{r} shows the total energy E .

$$E = E_0 v^2$$

- E_0 is invariant by space expansion because the kinetic and potential energies in radial direction \mathbf{e}_0 set off each other. E is also invariant.
- **Moving speed v in 3D is invariant by space expansion.**

Alternative expression of E :

$$E = mc^2 = m(C_r^2 + v^2)$$

- Intrinsic energy m is moving at c in a helical motion. C_r : circulating component, v : linear component
- Linear momentum of m is $\mathbf{p} = m\mathbf{v}$.
- m increases and c decreases by space expansion, keeping E constant.

< Simulation of motion of a circulating star in a galaxy >

x : radius of universe, r : radial distance of the star from the galactic center

$$r = r_0 \frac{x}{x_0}, \quad X \equiv x - x_0, \quad r = r_0 \left(1 + \frac{X}{x_0}\right)$$

Let 40 be x_0 and 137 be the current x as an example.

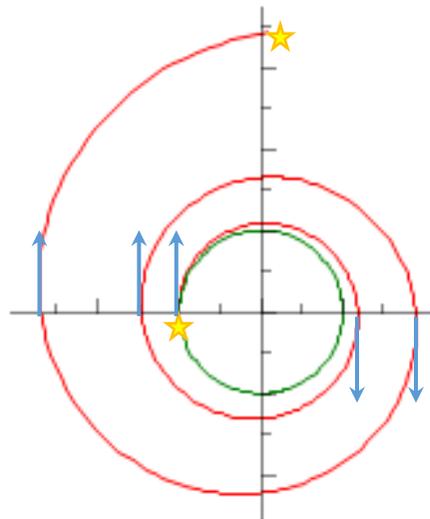
$$r = r_0(1 + X/40)$$

Circulating speed v is constant by space expansion.

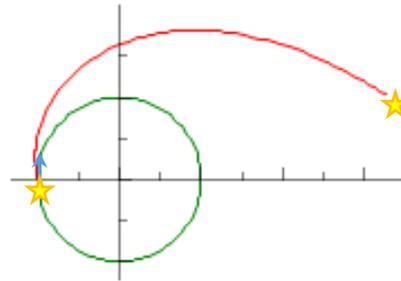
$$v = v_0 = \omega_0 r_0 \text{ (constant)}$$
$$\omega_r = \frac{v}{r} = \frac{\omega_0 r_0}{r} = \frac{\omega_0}{1 + X/40}$$

Location of the star:

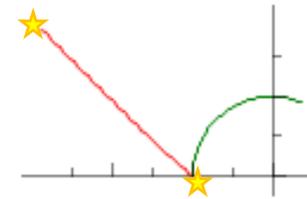
$$r[-\cos(\omega_r X), \sin(\omega_r X)]$$
$$= r_0(1 + X/40) \left[-\cos\left(\frac{\omega_0 X}{1 + X/40}\right), \sin\left(\frac{\omega_0 X}{1 + X/40}\right) \right]$$



(a) $v = 0.5 r_0$



(b) $v = 0.1 r_0$



(c) $v = 0.02 r_0$

Stellar motion with circulating speed $v = \omega_0 r_0$ from $x = 40$ to $x = 137$

$\omega_0 = 0.5$: circulation turns to a spiral motion by space expansion

$\omega_0 = 0.1$: firstly spiral then gets close to linear

$\omega_0 = 0.02$: almost a linear motion

If initial state of stars accords with $v^2 r_0 = K_0 M_0$, v^2 will be still inversely proportional to the radius r when the space expands by n .

$$v^2 r_0 = K_0 M_0 \text{ (at } r = r_0) \longrightarrow v^2 r = KM = nK_0 M_0 \text{ (at } r = nr_0)$$

< 4D spherical universe by the ECT >

Cosmic energy is circulating in two 2D planes in X_1 - X_2 and in X_3 - X_4 in 4D space.

$$\mathbf{x} = x_1 + ix_2 + jx_3 + kx_4$$

$$\mathbf{x} = [\mu_U \quad \boldsymbol{\theta}] = [\mu_U \quad \theta_1 \quad \theta_2 \quad \theta_3] \quad (\theta_1 = \theta_3 = \omega t)$$

$$\mathbf{x} = \mu_U (\cos \theta_1 + i \sin \theta_1 \cos \theta_2 + j \sin \theta_1 \sin \theta_2 \cos \theta_3 + k \sin \theta_1 \sin \theta_2 \sin \theta_3)$$

Take base vectors \mathbf{e}_0 for radius and \mathbf{e}_1 for arc.

$$\mathbf{e}_0 \equiv \cos \theta_1 + i \sin \theta_1$$

$$\mathbf{e}_1 \equiv \cos(\theta_1 + \pi/2) + i \sin(\theta_1 + \pi/2) = -\sin \theta_1 + i \cos \theta_1$$

Circulation in X_1 - X_2 ($\mu_U \mathbf{e}_0$ by radius) can be expressed by **arc** as $v t \mathbf{e}_1 = \mu_U \omega t \mathbf{e}_1$.

Circulation in X_3 - X_4 : $\mu_U (j \cos \omega t + k \sin \omega t)$

$$\mathbf{x} = \mu_U (\omega t \mathbf{e}_1 \cos \theta_2 + \sin \theta_2 (j \cos \omega t + k \sin \omega t))$$

θ_2 : locational parameter $0 \leq \theta_2 \leq \pi$

Apparent energy (asymmetrical part): moving by the formula

(Space energy: symmetrical in 4D space, energy of vacuum space)

- \mathbf{e}_1 forms 3D Cartesian coordinates with j and k .
- Circulating in \mathbf{e}_1 - \mathbf{e}_0 (**radial circulation**) and rotating in j - k (**space rotation**)

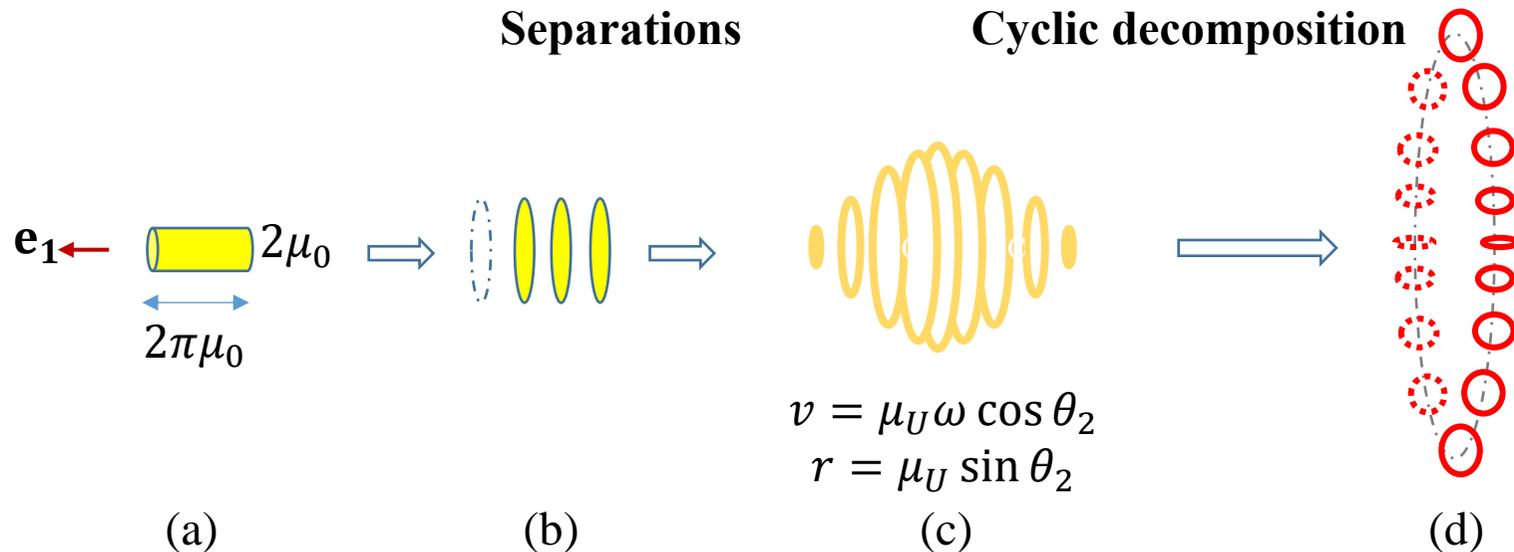
< Generation of initial galaxies >

Movements of the initial apparent energy in 3D space:

Linear movement in \mathbf{e}_1 : $\mu_U \omega t \cos \theta_2 \mathbf{e}_1$ (the radial circulation is linear in 3D)

Space rotation in j - k : $\mu_U \sin \theta_2 (j \cos \omega t + k \sin \omega t)$

With space expansion:



Separations and cyclic decomposition of the initial apparent energy

(a) Two ends are connected in \mathbf{e}_1 - \mathbf{e}_0 . (b) Separates to plural discs. (c) Each disc separates to plural circulations (different velocities / radiuses). (d) Each circulation decomposes to local circulations (**cyclic decomposition**)

[Radial expansion→Cyclic decomposition] repeat in plural rounds.

Then the cyclic decomposition gets hard for each circulation.

Huge number energy circulations constellated in a vast expanded 3D space

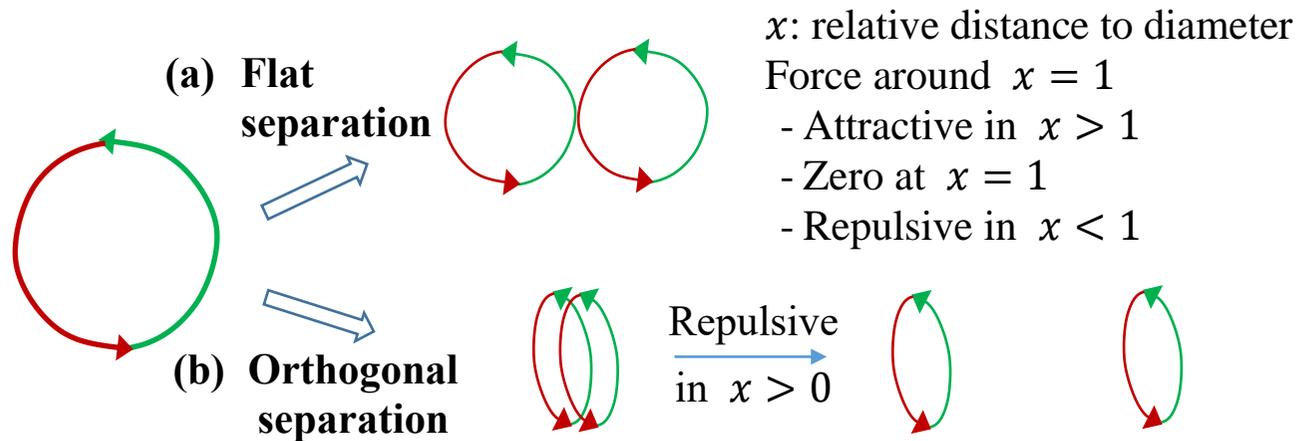
Resulted circulation:

$$\mathbf{E} = E\boldsymbol{\mu} = E\mu \exp(i\omega t) , \quad E = MV_c^2 = M\mu^2\omega^2$$

M can be a sum of partial ones of $n\omega$. $m\mu^2(n\omega)^2 = (n^2m)\mu^2\omega^2$

A single circulation in space-space dimensions can divide to two circulations by a **flat** or **orthogonal separation**. (Force / Potential energy: quantum particles)

$$MV_c^2 = M\mu^2\omega^2 \rightarrow (M_1 + M_2)V_c^2 = M_1\mu_1^2\omega_1^2 + M_2\mu_2^2\omega_2^2$$



Cascades of separations \Rightarrow a huge number of **galactic seeds**

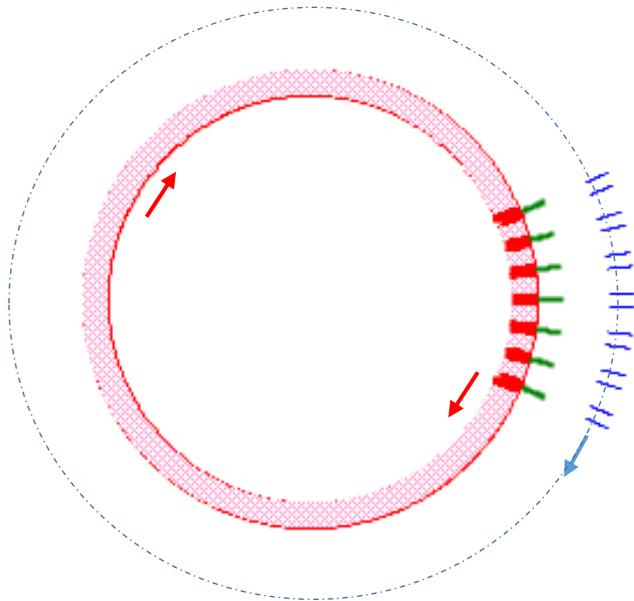
< Simultaneous releases of stellar seeds from a galactic seed >

Galactic seed:

$$E_G = M_G V_c^G{}^2, \quad M_G = \oint \Delta M_G$$

V_c^G : circulating velocity, invariant by space expansion

Each **local** intrinsic energy ΔM_G releases a stellar seed by inclined flat separation. It occurs simultaneously in almost whole circumference. A stellar seed may divide to two ones by orthogonal separation.



1) Force between a stellar seed and ΔM_G in the galactic seed:

○ ○ Relative distance to diameter increases. No longer attractive.

2) Force on a stellar seed from the whole circulation of the galactic seed is nearly zero.

3) **Intra-circulation force of a ring of stellar seeds** makes the whole seeds circulate in a ring.

Isolated stellar seed:

- Recede from the galactic seed **linearly** to the tangential direction at V_c^G .

A ring of stellar seeds released simultaneously:

- **Intra-circulation force** works on individual seeds.
- Continue to circulate within the ring at the original velocity V_c^G .
- If centrifugal force $>$ centripetal intra-circulation force: individual seeds show a spiral motion with radial increase but keep a ring in total.

< With space expansion >

- The radius of the ring expands but the circulating speed is kept constant.
- The galactic seed continues to intermittently release a ring of stellar seeds circulating at the same speed V_c^G .
- **Right-handed circulations** at a common speed of stellar seeds in a linear alignment over plural rings give a **left-turn spiral** alignment after expansion.
- It forms a **spiral disc of galaxy** with a **same circulating speed** at any radial distances.

Low circulating velocity of a galactic seed:

Elliptic galaxy

Two or more attached galactic seeds:

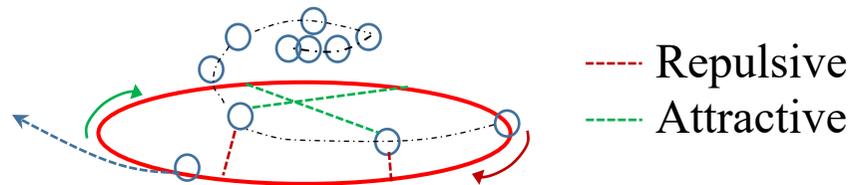
Barred spiral galaxy

Galactic seed exhausts energy and disappears early:

Ring galaxy

< Orthogonal release of a stellar seed >

- Stellar seed release from a local intrinsic energy ΔM_G is possible also to **orthogonal** or **intermediate** directions to the galactic seed.
- Not simultaneously, but release one by one from a local intrinsic energy.
- Released seed receives a repulsive force from the neighboring site of the galactic seed and an attractive force from the opposite site.
- It moves spirally to the center and orthogonal direction, then stops.
- After space expansion, elliptical sphere distribution of stellar seeds is formed. It is a **bulge** of a galaxy.
- Stellar seeds near the center are stationary. With apart from the center, they rotate if within the galactic seed radius.
- **Intermediate directional** release: A seed recedes linearly to a mix direction of tangential and orthogonal. Form **globular clusters** or separate pieces.



< Evolution of a stellar seed to a stellar system >

Intrinsic energy M_S of a stellar seed gets hard to circulate by a unique frequency in the whole. It starts to release energy pieces by flat separation in two types.

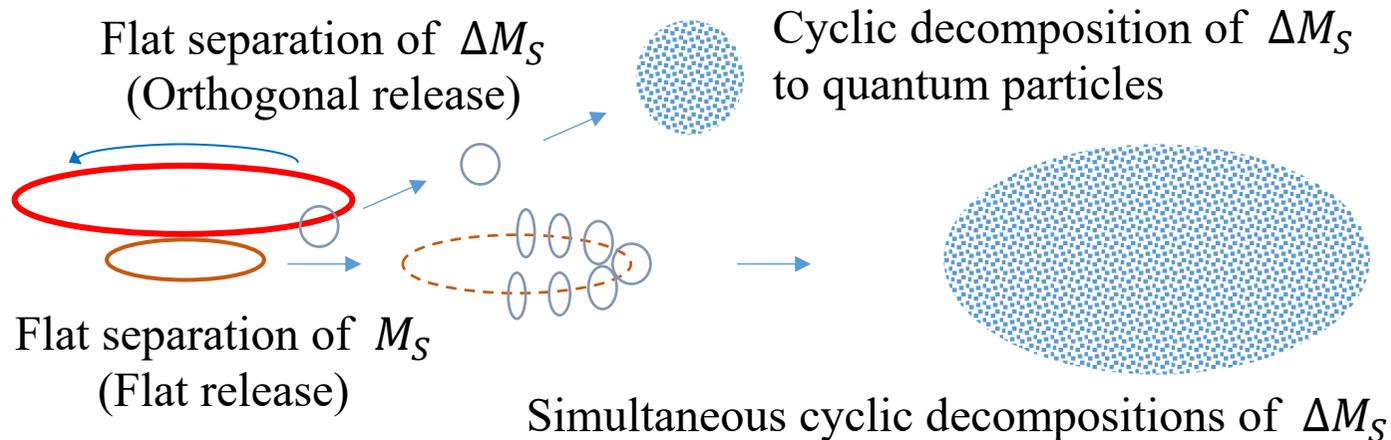
1) Inclined flat separation of M_S (**Flat release**)

- Released piece recedes in the tangential direction within the plane of the stellar seed. It decomposes to local intrinsic energies ΔM_S by cyclic decomposition.

2) Flat separation of a local intrinsic energy ΔM_S (**Orthogonal release**)

- Release directions are orthogonal or intermediate, but majority are in vicinity to the stellar seed plane.

Released energy pieces (separated ΔM_S) decompose to smallest level energy circulations (quantum particles) by cyclic decomposition.



Smallest energy circulations with the radius μ_0 (quantum particles):

$$E = mv_c^2, \quad v_c = \mu_0\omega_0$$

- The intrinsic energy m can be divided to plural ones if large enough.
- m_0 is the smallest value of m . $m_0v_c^2$ is an **elementary circulation** called single circulation (iS or S), which composes other **quantum particles**.

Forming a stellar system:

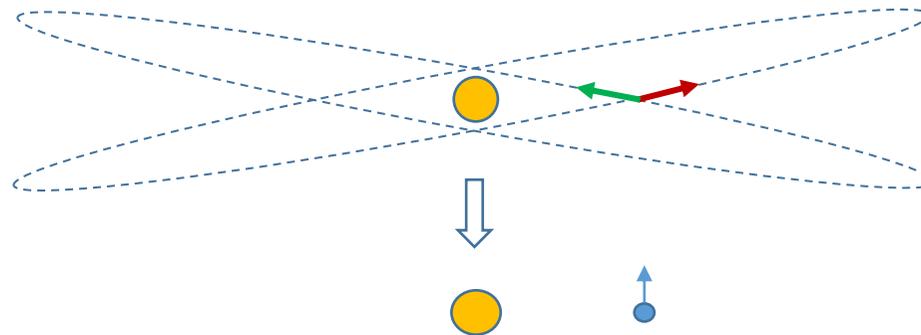
- Energy piece release from a stellar seed is not simultaneous. The intra-circulation force does not work on each energy piece. Released energy piece recedes from the stellar seed linearly.
- Gravitational force becomes not negligible, and decelerates the receding speed of the energy piece, which shows an elliptical motion.

<In case of flat release>

- Because the stellar seed successively releases energy pieces for a notable duration, released pieces in the common plane interact each other by the fundamental force and the gravitational force.

- They form energy clusters, which orbit around the stellar seed (see the figure below). They obey the relation $v^2 r = KM$. (K is the gravitational constant G this case.)
- By cyclic decomposition, the **stellar seed itself** finally decomposes to quantum particles, which form a **main star** at the center.

Thus, a **proto-stellar system** has shaped up, consisting of a **proto-star**, **protoplanetary discs**, and other energy pieces.



< Observation of galactic seeds and stellar seeds >

- Local intrinsic energies ΔM_G of a galactic seed and ΔM_S of a stellar seed include **hidden-space** dimensional circulations iS .
- Rotation of iS in the plane of a galactic or stellar seed **around a space axis** causes a **light radiation** in the plane. (See Light radiation)
- An **early stage galactic seed**, the radiation from which we observe now, should be a **quasar**.
- With increase of stellar seeds and quantum particles decomposed from them, the galactic seed radiations are trapped and become opaque. We can see only early stage galactic seeds.
- A **remaining galactic seed** corresponds to a **black hole** at a galactic center by the standard physics.
- **Stellar seeds** before star generation, such as in the most **inner ring(s)**, radiate lights like galactic seeds. It corresponds to an **accretion disk** surrounding a black hole by the standard physics, while it should be an **excretion disk** from a galactic seed.

< Cosmic microwave background >

- **Light radiations** occur also in **early stage energy circulations** from the beginning of the space expansion.
- Such early energy circulations also release low-energy pieces, which form various quantum particles.
- The radiated lights interact with quantum particles.
 - Light activates and prolongs an iS in a quantum particle to a plus-minus pair of electric charge. A prolonged iS radiates a light, returning to a lower energy level.
- These interactions with early matters (quantum particles, plasmas, atoms) make the **whole radiated waves** be **in equilibrium**.
- After expansion, the space becomes **transparent** for **light propagation**.
- The light waves are **largely redshifted** now by the space expansion.
- This is the **cosmic microwave background**.

< Balance of the centrifugal force and the intra-circulation force >

Centrifugal force formula $F_{\perp} = m\omega^2\mu = mV_c^2/\mu$:

Based on the **mass**, which is the **intrinsic energy moving at c** .

Fundamental force constant K_f : depend on the moving speed of intrinsic energy.

Select $c = v_c = \mu_0\omega_0$ (current light speed) as the **common moving speed**.

c : velocity in a helical motion, V_c : linear component, $E = mc^2 = m(C_r^2 + V_c^2)$

$$E = Mc^2, \quad \Delta E = mc^2, \quad p = MV_c = \frac{E}{c^2}V_c, \quad \Delta p = mV_c = \frac{\Delta E}{c^2}V_c$$

$$cF_{\perp} = -K_f \frac{p\Delta p_0}{2\pi\mu^2} = -K_f \frac{E\Delta E V_c^2}{2\pi c^4 \mu^2} = -\frac{K_f V_c^2 Mm}{2\pi \mu^2}$$

$$\frac{mV_c^2}{\mu} - \frac{K_f V_c^2 Mm}{2\pi \mu^2} = 0, \quad \mu = \frac{K_f}{2\pi} M = \frac{K_f}{2\pi c^2} E$$

The balanced **radius** is **proportional** to the **energy** (independent of V_c).

By energy release, the **radius reduces** but V_c is constant.

$$E = M_0 V_c^2 \rightarrow E = (M_1 + M_2) V_c^2$$

This presentation is extracts from

- 1) S. Nagao, Galactic evolution showing a constant circulating speed of stars in a galactic disc without requiring dark matter, *Rep. Adv. Phys. Sci.* **4**(2) (2020) 2050004.
<https://doi.org/10.1142/S2424942420500048>

Please also refer to

- 2) S. Nagao, Structures and interactions of quantum particles based on the energy circulation theory, *Rep. Adv. Phys. Sci.* **3**(1) (2019) 1950001.
<https://doi.org/10.1142/S2424942419500014>
- 3) S. Nagao, Energy circulation theory to derive the cosmic evolution, electric charge, light and electromagnetism, *Rep. Adv. Phys. Sci.* **2**(3) (2018) 1850007.
<https://doi.org/10.1142/S242494241850007X>
- 4) S. Nagao, Frequency-based redshift for cosmological observation and Hubble diagram from the 4-D spherical model in comparison with observed supernovae, *J. Phys.: Conf. Ser.* **880** (2017) 012058.
<https://doi.org/10.1088/1742-6596/880/1/012058>

Correction: After the energy circulation theory, formulas for frequency-based and wavelength-based redshifts are revised. Please see the below pdf.

<http://www3.plala.or.jp/MiTiempo/HubbleDiagram.pdf>