種々の銀河形状の形成

エネルギー周回理論に基づく

Version-2023.01

銀河種分離の終了 ⇒ **恒星種放出**が始まる

銀河種の局所内在エネルギーの不均一水平分離

銀河種からの**恒星種放出の種類**:

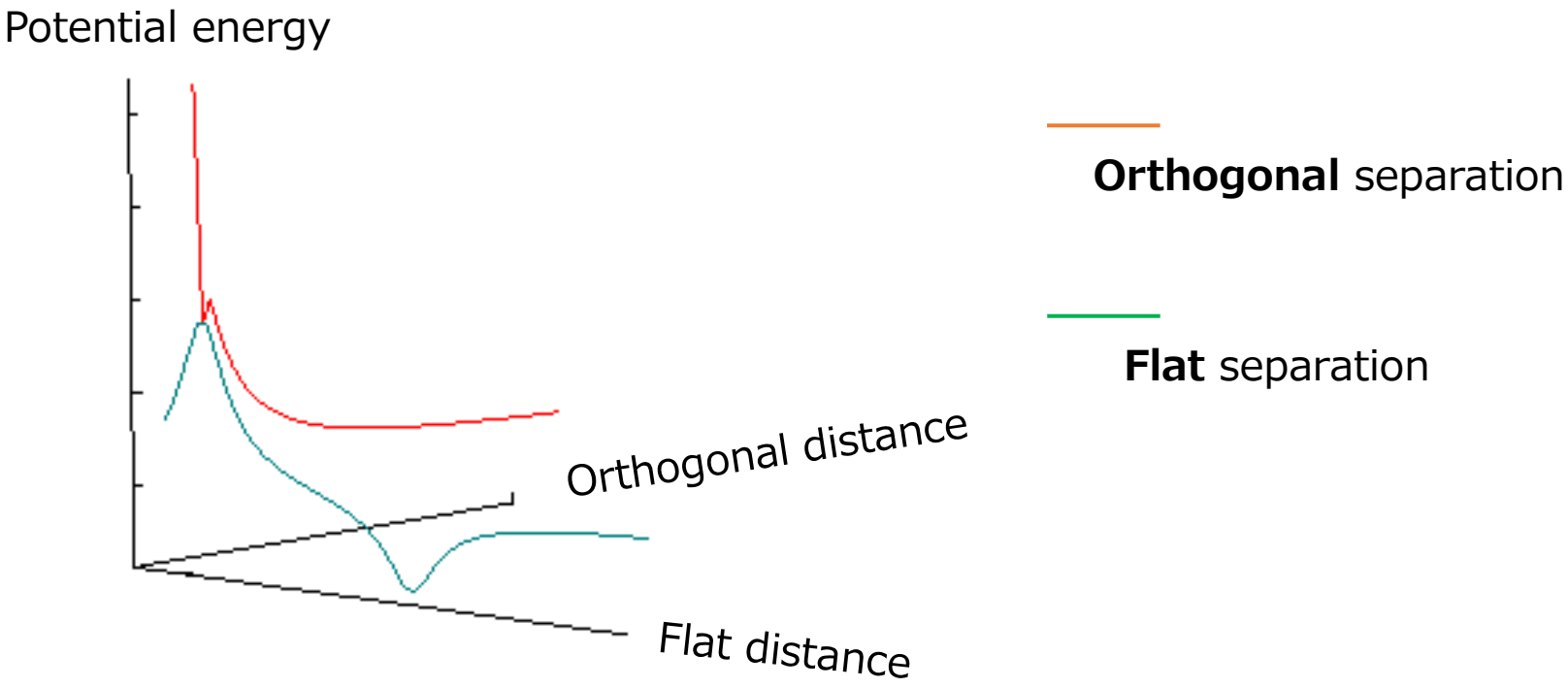
1. **直線状放出**
   - ランダムにおよび連続的に恒星種が放出され、直線運動する。
   - 水平放出と垂直放出がある。
2. **環状放出**
   - 円周全体で同時に水平放出が起こる。

     恒星種が**環状**に分布（**恒星種環**） ------ **周回内力**が働く

     宇宙膨張で半径が増加するが、引き続き周回する。
   - 恒星種環は断続的に放出される。

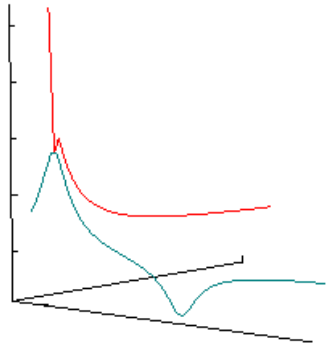
恒星種を放出する**銀河種の分類**：

ガンマ線バーストと同じ分類を使う。



Change of **potential energy** in a **galactic seed separation** released as radiation (**gamma-ray burst**, gravitational wave)

銀河種分離後の**銀河種**:



Type-1 GRB:

- 垂直分離のエネルギー谷で十分な分離速度。
- 垂直分離のみで、水平分離は伴わない。
- 二つの銀河種は**引き続き垂直方向に遠ざかる**。

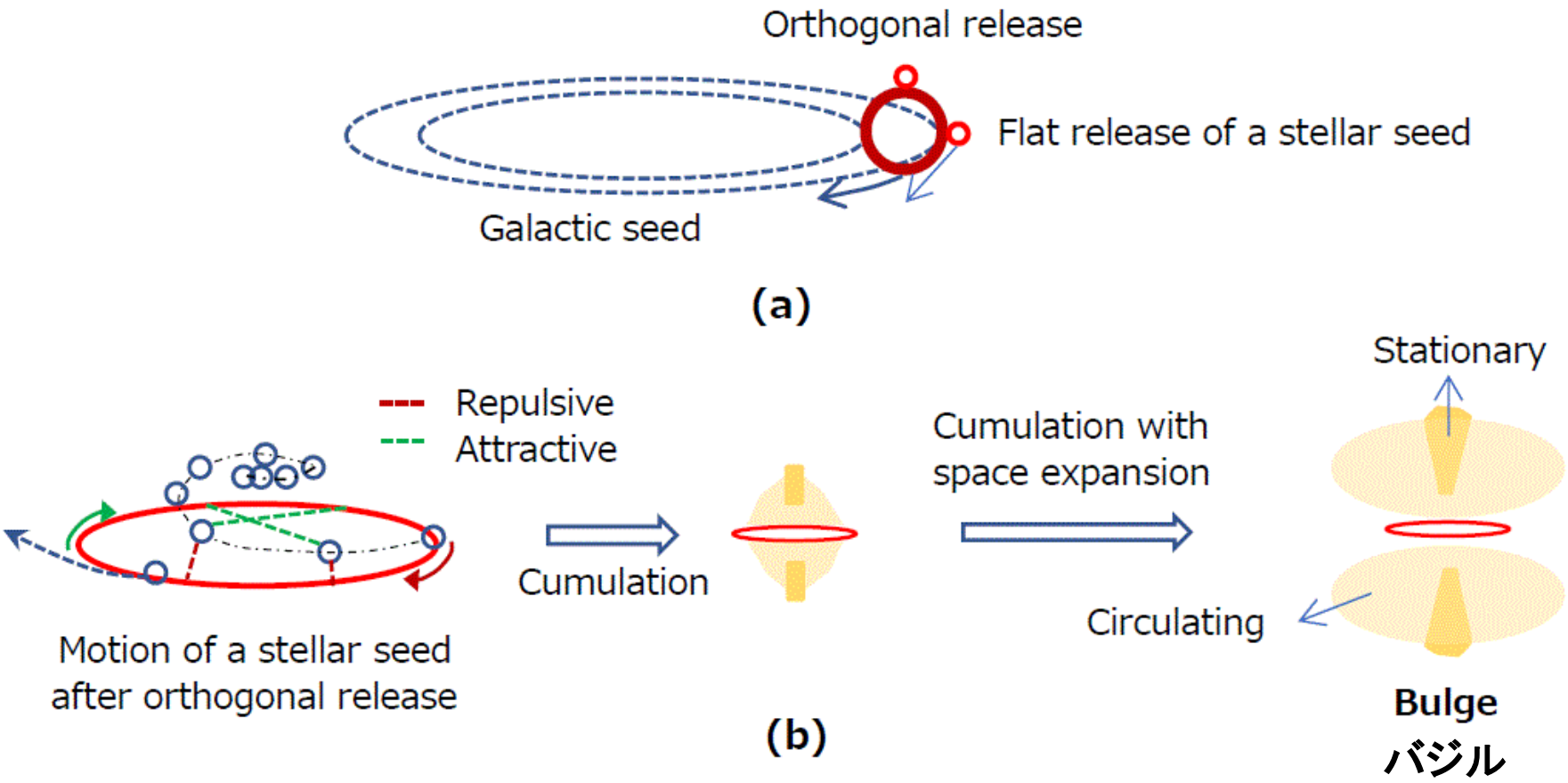
Type-2 GRB:

- 垂直距離はエネルギー谷周辺で振動し、静止する。
- 垂直分離の谷から次の水平分離が始まる。
- 水平分離のエネルギー谷での速度が大きい場合、距離は増加し続けるか**静止し、収縮はしない**。

Type-3 GRB:

- 水平分離での速度が十分には高くない。
- 銀河種間の距離がエネルギー谷で振動し放射でエネルギー放出した後、谷で停止する。
- **隣接した二つの銀河種**となる。

Type-1: galaxy formed from a **single galactic seed**（単一銀河種から）

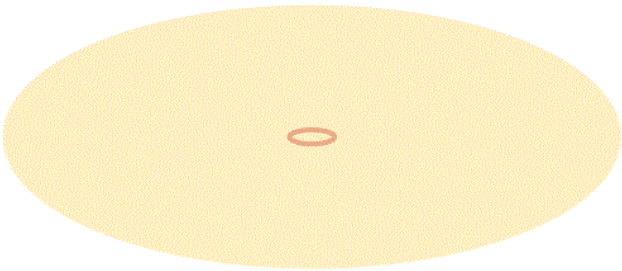


Linear releases of stellar seeds

水平および中間方向の放出 → 楕円銀河やハローを形成する

垂直放出 → バルジ構造を形成する

Type 1-1: By independent linear releases



(a) **Elliptical galaxy** **楕円銀河**

Simulation using an exponential time unit:

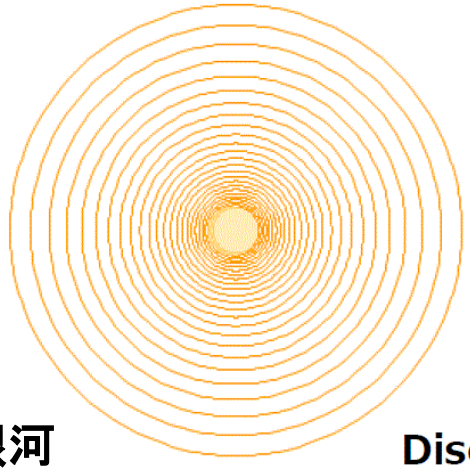
For $T_{1.1} = m$, the space expands by 1.1^m times. Present: $m = 0$

$r_0 = 1.1^m r_m$, r_m: radius at $T_{1.1} = -m$

Ring releases: occur intermittently once per $T_{1.1} = 1$

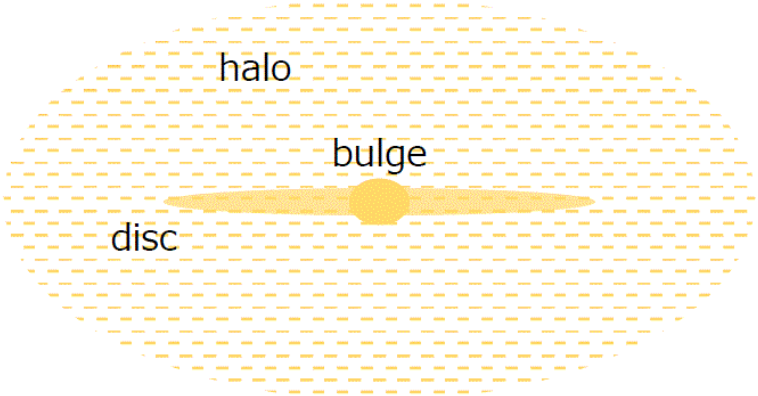
(Reported 42 shells of NGC 3923 show this interval.)

Type 1-2: By simultaneous flat releases in a ring (**ring release**)



NGC 3923

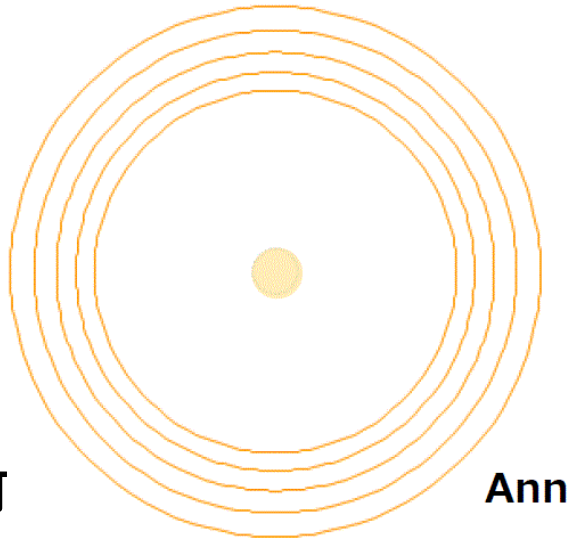
NGC 691



円盤銀河 **Disc galaxy** (disc + bulge)

(b) Intermittent ring releases once per $T_{1.1} = 1$ ($T_{1.1} = -24$ to 0)

$[x_m, y_m] = R_m[\sin t, \cos t], R_m = 1.1^m \quad (0 \le t \le 2\pi)$ $(m = 0$ to $24)$



Hoag's Object

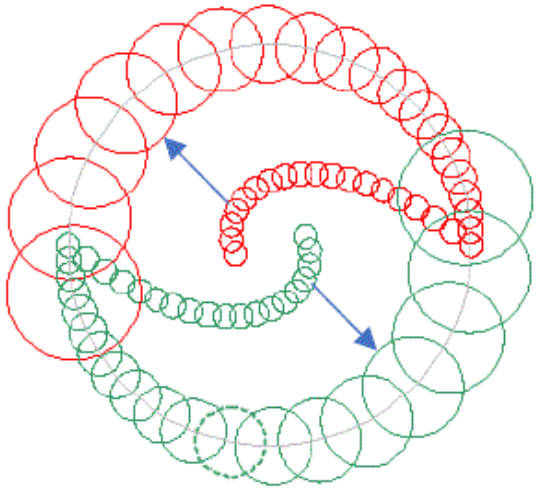
金環銀河 **Annulus galaxy** (rings+ bulge)

(c) Galactic seed released rings then exhausted ($T_{1.1} = -26$ to -22).

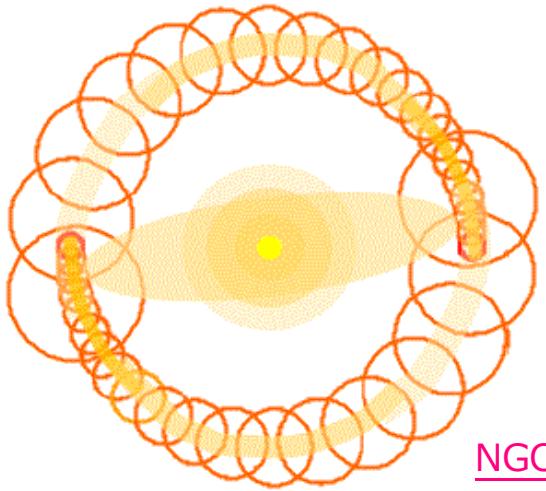
Type-2: galaxy formed from **rotating binary galactic seeds**

Type 2-1: By intermittent **ring releases**

Type 2-1: By intermittent ring releases from rotating binary galactic seeds



(a) Intermittent ring releases



NGC 5728

(b) **Barred ring galaxy 棒状環状銀河**

$$T_{1.1} = -18 \text{ to } 0: r_m = 1.1^m.\ R_0 = 3 * 1.1^{18},\ \theta_m = 0.236\pi(1.1^m - 1)$$

$$R_m = 3 * 1.1^{18-m}\ ,\quad m = 0 \text{ to } 18$$

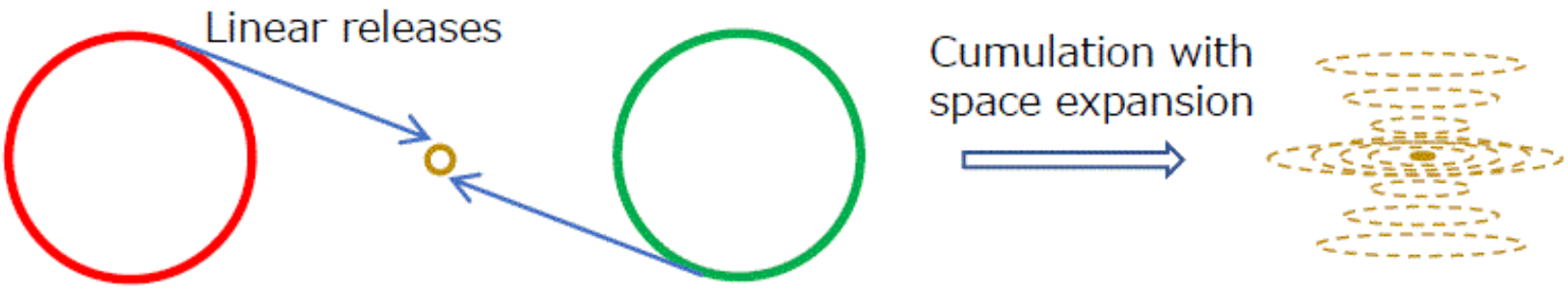
Galactic seeds: $[x_m, y_m]_1 = [\sin t + R_m \cos\theta_m\,, \cos t + R_m \sin\theta_m]$

$[x_m, y_m]_2 = [\sin t - R_m \cos\theta_m\,, \cos t - R_m \sin\theta_m]$

Released rings: $[x_m, y_m]_1 = [r_m \sin t + R_0 \cos\theta_m\,, r_m \cos t + R_0 \sin\theta_m]$

$[x_m, y_m]_2 = [r_m \sin t - R_0 \cos\theta_m\,, r_m \cos t - R_0 \sin\theta_m]$

Formation of a **bar-bulge**（バーバジルの形成）

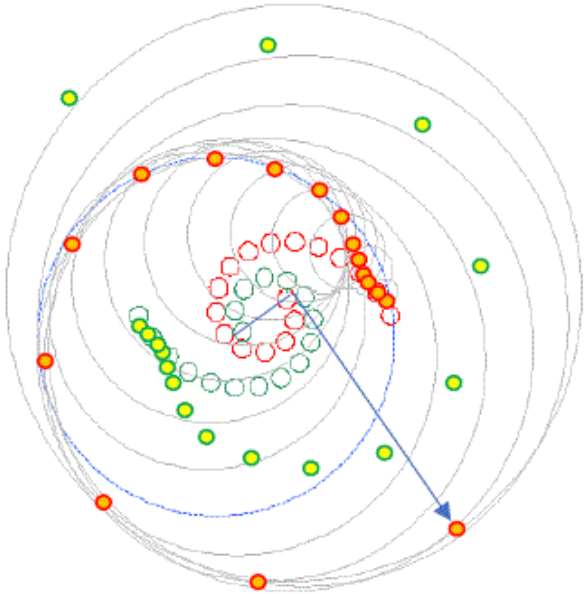


(c) Formation of a "**bar-bulge**" of stellar seeds

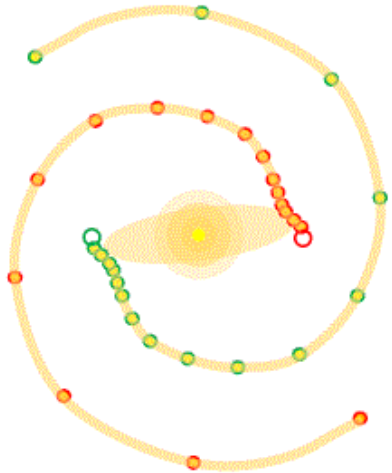
Circulations are formed not limited at the center, spreading on the line.

(d) Distribution of **bar-bulges**

Type 2-2: By **linear releases** from two outer-ends of rotating binary galactic seeds



(a) Released stellar seeds from two ends move linearly.



NGC 1300

(b) **Barred arm galaxy** (with bar-bulge)

棒状アーム銀河

$$T_{1.1} = -16 \text{ to } 0 : \; V_{1.1} = 1.2 \,, \; R_m = 3 * 1.1^{(16-m)} \,, \; \theta_m = 0.613\pi(1.1^m - 1)$$

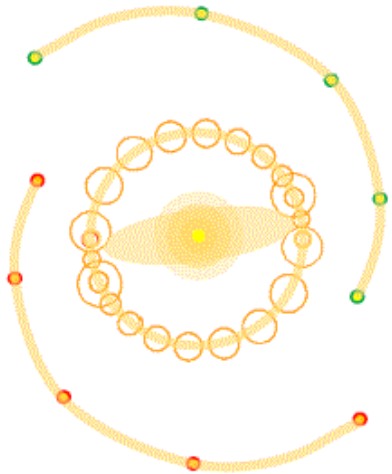
Short duration of linear releases:

$T_{1.1} = -16 \; to - 12$: Linear releases

$T_{1.1} = -11 \; to \; 0$: Ring releases

$r_m = 1.1^m \,, R_0 = 3 * 1.1^{16}$

$\theta_m = 0.613\pi(1.1^m - 1)$



NGC 2217

棒状環状アーム銀河

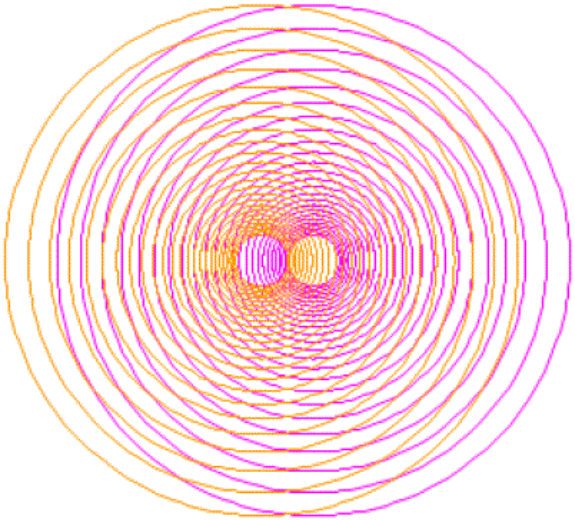
(c) **Barred ring-arm galaxy**

Type-3: galaxy formed from **two attached galactic seeds（二つの隣接銀河種）**

Type 3-1: By **intermittent ring releases** from two attached galactic seeds

Rings are released once per $T_{1.1} = 1$ from $T_{1.1} = -24$ to 0: **Double-disc galaxy**

二重円盤銀河



Andromeda Galaxy

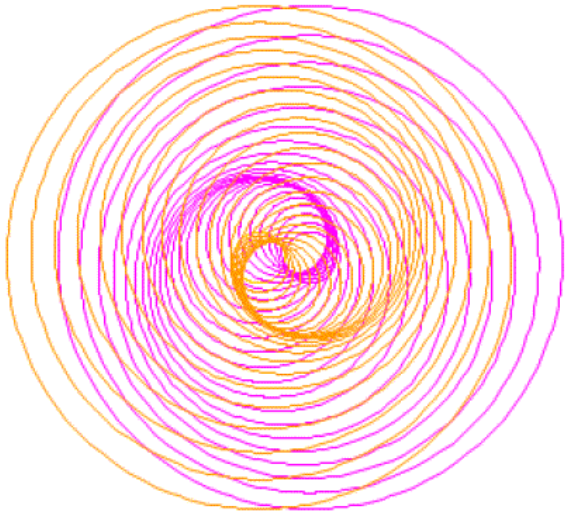
(a) No rotation of galactic seeds $\Omega_{1.1} = 0$

$$[x_m, y_m]_1 = [r_m \sin t + \cos(m\Omega_{1.1}), r_m \cos t + \sin(m\Omega_{1.1})]$$

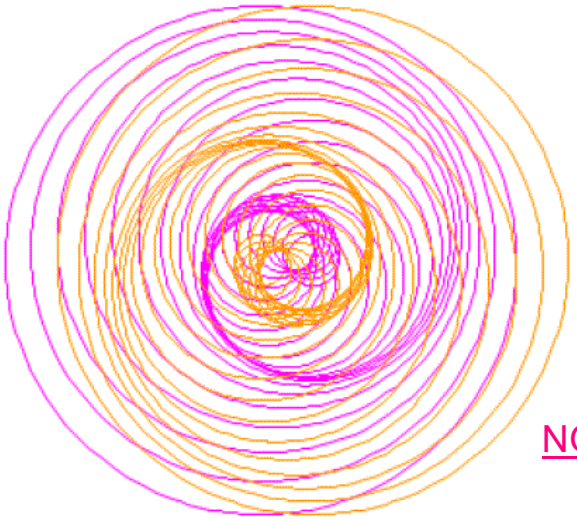
$$[x_m, y_m]_2 = [r_m \sin t - \cos(m\Omega_{1.1}), r_m \cos t - \sin(m\Omega_{1.1})]$$

$$r_m = 1.1^m, \qquad \Omega_{1.1} = 0\ (a), \frac{\pi}{12}\ (b), \frac{\pi}{8}\ (c), \frac{\pi}{6}\ (d) \text{ or } \frac{\pi}{4}\ (e)$$

$$m = 0 \text{ to } 24, \qquad 0 \le t \le 2\pi$$

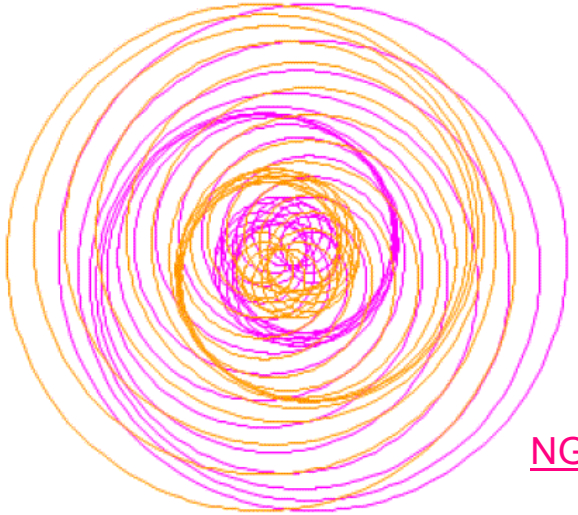


(b) Rotation by $\Omega_{1.1} = \pi/12$



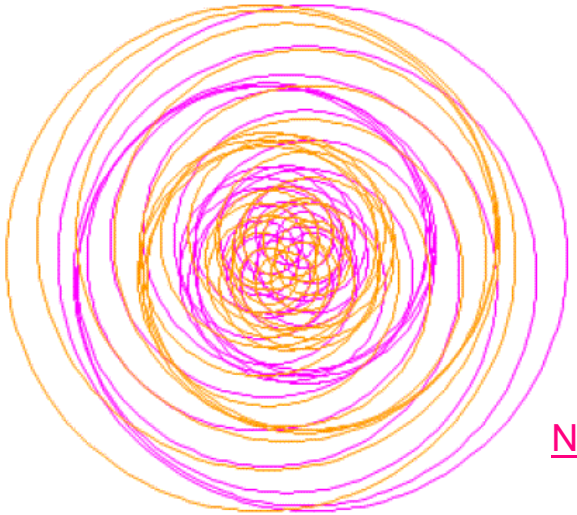
NGC 5861

(c) Rotation by $\Omega_{1.1} = \pi/8$



NGC 6384

(d) Rotation by $\Omega_{1.1} = \pi/6$



NGC 3147

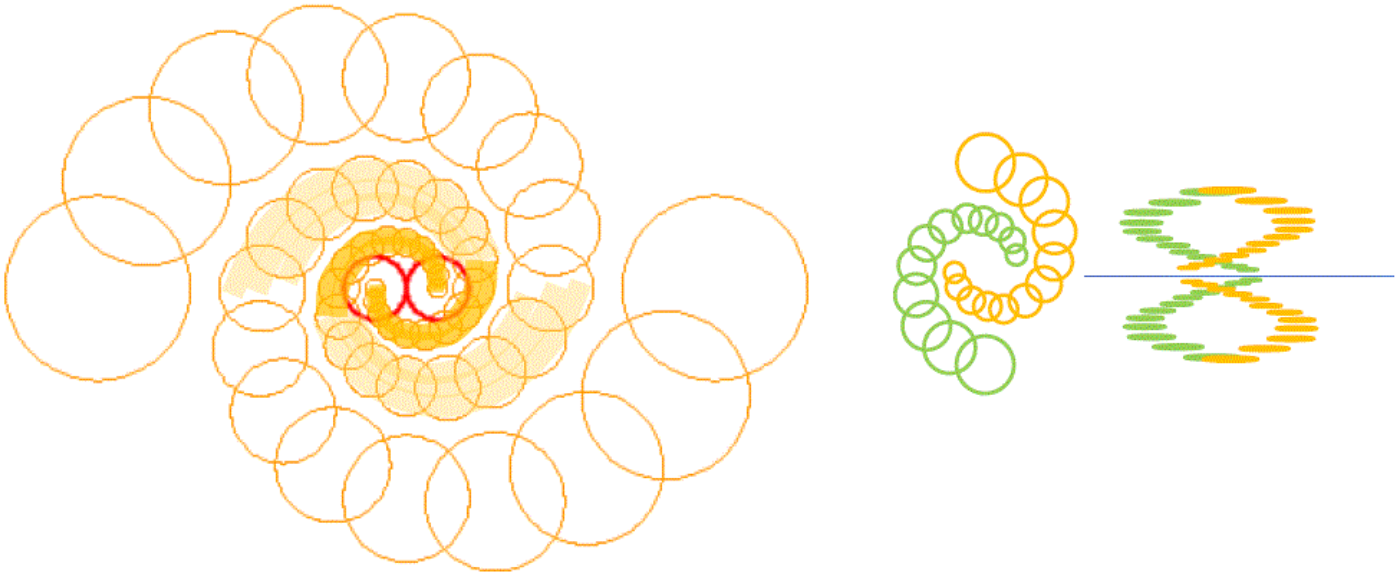
(e) Rotation by $\Omega_{1.1} = \pi/4$

Double-disc galaxy showing spiral arms: **Spiral double-disc galaxy 渦巻二重円盤銀河**

Bulges of non-rotating attached galactic seeds:

Respectively remain over/under the two galactic seeds.

Bulges of a spiral double-disc galaxy:



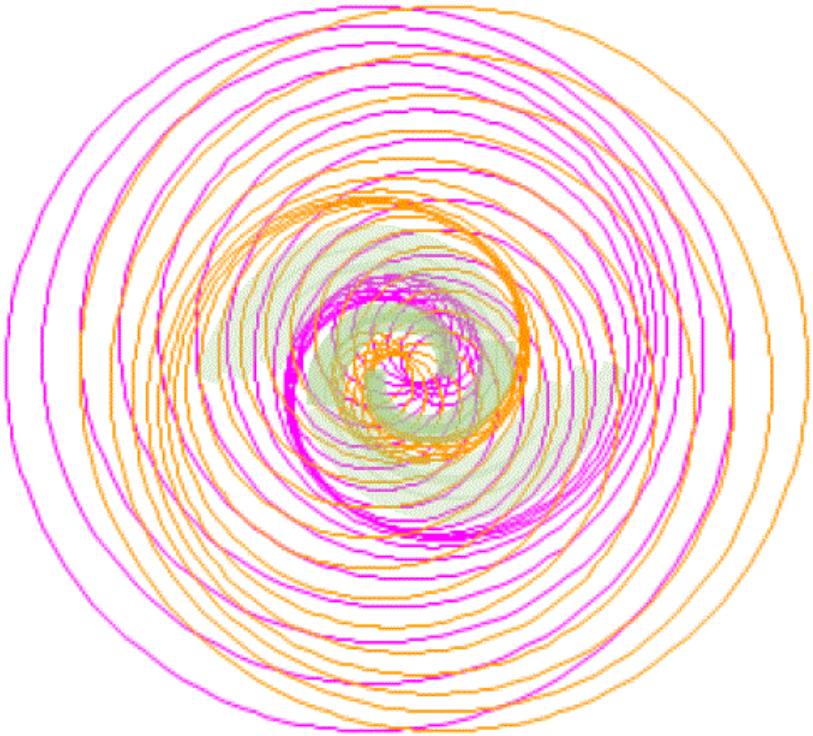
(a) Bulge: $T_{1.1} = -24 \text{ to } 0$, $\Omega_{1.1} = \pi/8$, $r_{bulge} = 0.3$

$$[x_m, y_m]_1 = [r_m \sin t + R_m \cos(m\Omega_{1.1}), r_m \cos t + R_m \sin(m\Omega_{1.1})]$$

$$[x_m, y_m]_2 = [r_m \sin t - R_m \cos(m\Omega_{1.1}), r_m \cos t - R_m \sin(m\Omega_{1.1})]$$

$$r_m = 0.3 * 1.1^m , \qquad R_m = 1.1^m , \qquad \Omega_{1.1} = \pi/8$$

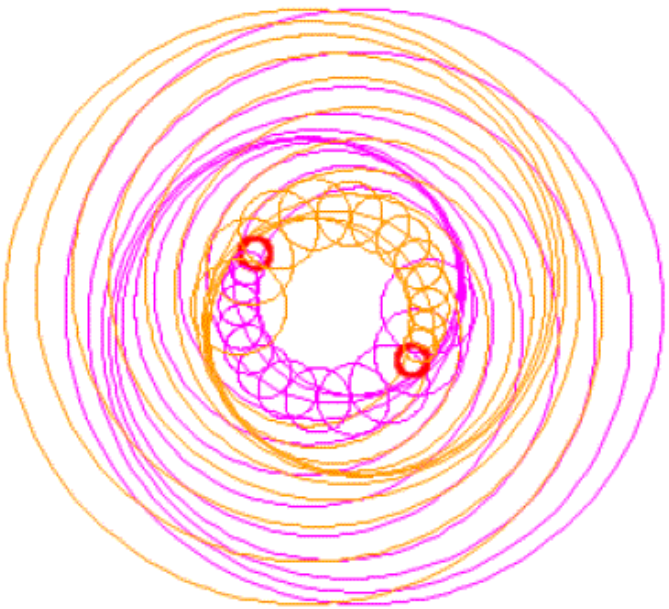
Overall appearance of the galaxy (double-disc + bulge)



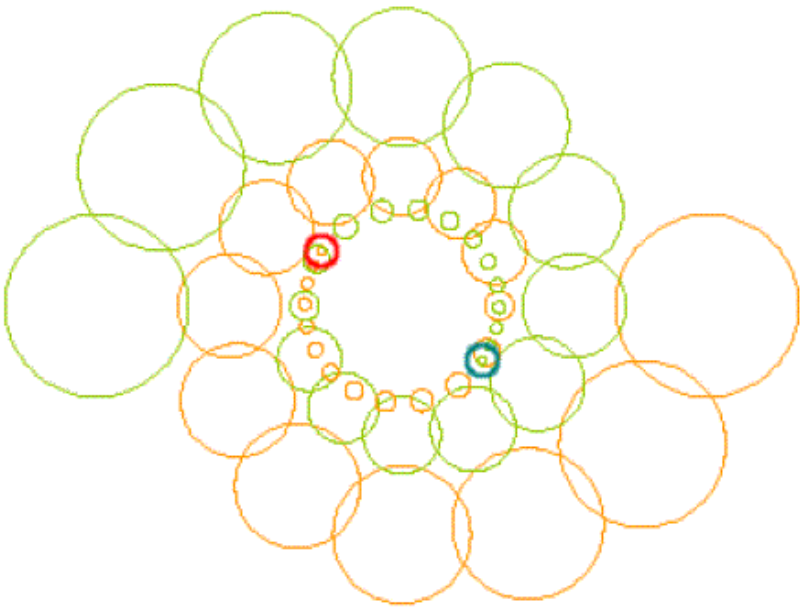
(b) **Spiral double-disc galaxy** ($T_{1.1} = -24$ to 0 , $\Omega_{1.1} = \pi/8$)

渦巻二重円盤銀河

Type 3-2: By ring releases from rotating two galactic seeds firstly attached then receding by the space expansion （当初は隣接、その後離れる）



(a) Disc by ring releases



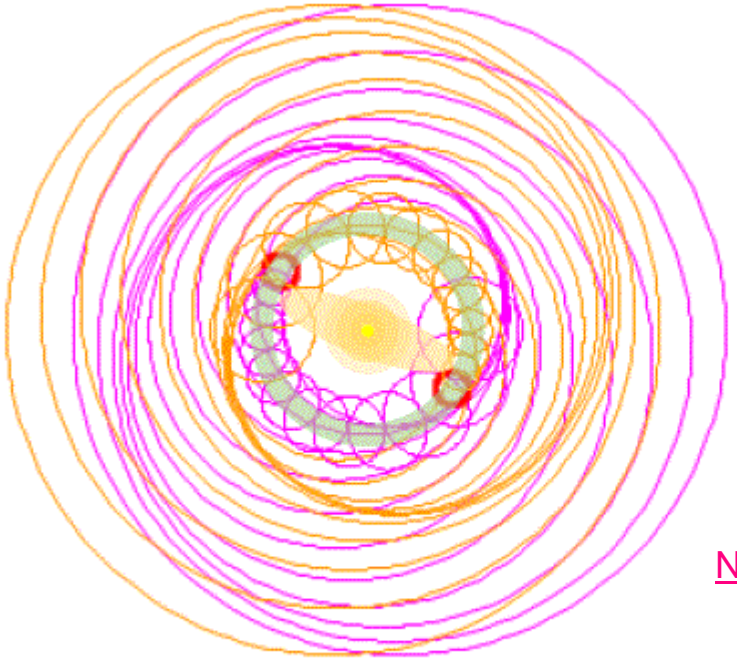
(b) Bulge by orthogonal releases

(1) $T_{1.1} = -24$ to -13 : $r = 1$, $R = 1$, $r_{bulge} = 0.3$, $\Omega_{1.1} = \pi/6$

(2) $T_{1.1} = -12$ to 0 : $r = 0.5$, $R_m = 1.1^m$, $R_0 = 1.1^{12} = 3.14$, $r_{bulge} = 0.15$,

$\theta_m = 0.557\pi(1.1^m - 3.138)$

Overall appearance of the galaxy (double-disc & ring + bulge + bar-bulge)



NGC 105

(c) Barred ring & double-disc galaxy

棒状環状二重円盤銀河

Published paper:

S. Nagao, Formation of Major Types of Galaxies Based on the Energy Circulation Theory, *Rep. Adv. Phys. Sci.* **6** (2022) 2250004.

https://doi.org/10.1142/S2424942422500049

Website:

Energy Circulation Theory (ECT) home

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