Programming modeling of forming of galaxies spiral arms

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Annotation. A hypothesis was represented of a formation of galaxies spiral arms in result of an impression of streams of high-energetic particles streams (plasma) form galaxy's cores onto its gas and dust environment. The source of the plasma are satellites of a supermassive black hole (SMBH) in the center of a galaxy, and there could be several such satellites. Such satellites should be fast rotating star mass objects such as accretion disks of black holes or pulsars. A programming model is suggested to simulate such process and to compare results of modeling with photographs of real galaxies. This shown that the model is very close to describing real physical phenomena. On example of modeling spiral arms of some galaxies it was demonstrated the versatility of the given model and its practical applicability to any spiral galaxy. In part, a model of the galaxy M31 was represented with 21 satellites and corresponding spirals as well as models of other galaxies (M51 Whirpool, Large Magellanic Cloud etc.) There was noted a possible relation between supernova flares and an impression of the plasma from galaxy's cores onto stars.

Keywords: galaxy, black hole, elliptic orbit, tide forces, accretion disk, plasma stream, spiral arms, galaxy evolve, modeling of galaxies, supernova

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Introduction

Hypothesis. The spiral arms of galaxies are not formed once at some time and then save its form stable. Instead these are constantly growth from the inner to outside. Or, exactly, the gas and dust continue rotating on its orbits around the galaxy center, but streams of high-energy particles are emitted from the galaxy's core. And such streams force the gas and dust to shine, swirl and form new stars.

The central supermassive black hole (SMBH) has several satellites of star masses and some of those are rotating with a high speed over its axis. We know two kinds of such objects:

- Pulsars [3];
- Black holes (their accretion disks) [4].

Its rotating speed is so big that the matter particles on its surfaces have a linear velocity which can be close to the speed of light. Still the satellites are near to SMBH then tide waves are forming on their surfaces. In result in some two points on their surfaces the matter is broken off them and then it flies to space in two opposite directions. And further the particles emitted are moving along strait lines with the constant speed. While the satellite continue its movement on its elliptic orbit and the direction of emitting particles is changing slowly.

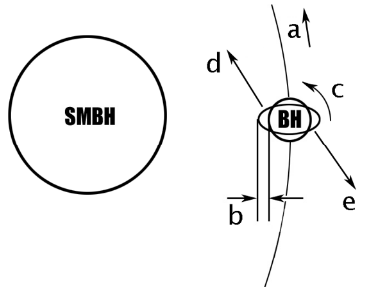

Figure 1. Forming of two opposite directed streams of particles (d, e)while moving a black hole or pulsar (BH) around on its orbit (a) around a SMBH, when a tide wave (b) forces a matter swirling to brake off the satellite (c).

In result a double spiral is forming in space.

Modeling of galaxies

To prove the hypothesis a programming model was implemented to simulate such physical process. Following suggestions were accounting relating the process modeled:

1. the (initial) plasma speed is changing linearly on a satellite of a SMBH from a value v1 at the pericenter to a value v2 on a maximal distance from the SMBH,
   $v = v1 + (v2 – v1) * (r – q) / (Q – q)$,

   where:

   - v1 – minimal speed, $0 < v1 \leq c$,
   - v2 – maximal speed, $0 < v2 \leq c$,
   - r – current distance from the satellite to the SMBH,

q – minimal distance from the satellite to the SMBH (in the pericenter),

   - Q – maximal distance from the satellite to the SMBH ($Q= 2a – q$);
2. an angle between a line of the plasma emission and a line connecting the satellite to the SMBH also is changing linearly between two values d1 and d2:
   $d = d1 + (d2 – d1) * (r – q) / (Q – q)$,
   $0 \leq d1 \leq 180$, $0 \leq d2 \leq 180$;
3. the plasma is emitted either in the plane of the satellite ecliptic (ψ=90), or along a surface of a double cone formed by the elliptic orbit of the satellite ($0<\psi<90$), and which axis is perpendicular to the satellite orbit's ecliptic plane.

Also there was a direction was taking into account from which the Earth's observer is looking to the satellite trajectory (and to the spiral formed by it), so following parameters were added:

1. the rotating angle of the projection plane (from 0 to 360 degrees);
2. the inclination of the projection plane (from -180 to +180 degrees, where negative values are corresponding to the inclination of the top side out of the observer);
3. the final rotation of the line along which the plasma is emitting at the observing time (from 0 to 360 degrees); or this can be marked as "starting angle" if to start swirling the spiral from the center to bounding edges of a galaxy.

Also following parameters were introduced:

1. the window size where the project plane is shown (in light years), used to scale the spiral;
2. the SMBH mass (in masses of the Sun) – it was used to calculate values:
   - a (major semi-axis of the elliptic trajectory of the satellite);
   - q (distance to the SMBH in a pericenter);
   - Q (maximal distance to the SMBH).

The program in obligatory order takes into account geometry distortion of the arms which is a result of very high velocities of the plasma movement. Because of the restricted in time of a signal distribution by the speed of light the arms moving from us are condensing visually while those of them which are moving toward us are stretching out a lot. This is a simple school task about a simultaneous arrival on a station of two trains moving along two different ways. These "trains" (plasma streams) are starting from the O point to the E point through the points A and B' with the speed v=kc on sections OB' and OA, and with the speed v=c on sections B'E and AE, correspondingly.

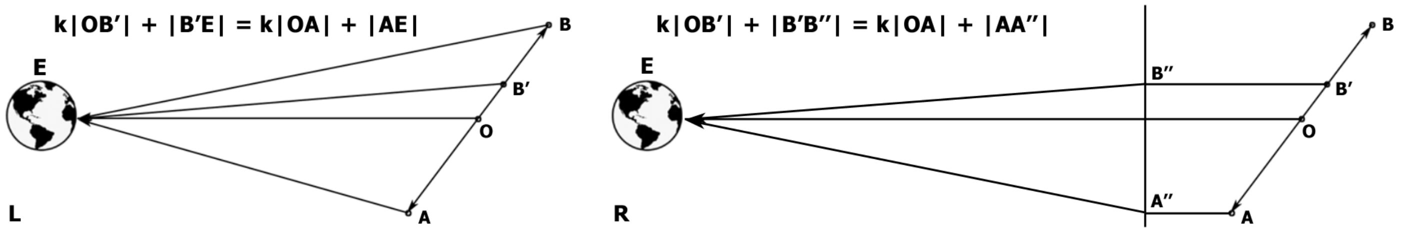

Figure 2. The geometry distortion of paths of objects moving fast in space while observing them from the Earth. L – physically exact task representation, R – an approximation of the task.

To optimize calculation and to remove a dependency from a distance to an object (galaxy) a simplified scheme R is used still we know that the distance to a galaxy anyway is so large that we can assume two distances |B"E| and |A"E| very close to each other with a very high precision.

To make it possible to use the program for a visual comparison of modeling results with photographs of galaxies, these images of galaxies can be used as a background while drawing spirals built by plasma emitted by satellites. It is possible to work with several satellites simultaneously or sequentially. Also there are many other parameters in the program taking effect on its exterior (color, lines width etc.).

Comparing photographs of galaxies with its models

There are several comparisons of models of some galaxies with its astrophotography below. In some cases there are tables with orbits parameters of corresponding satellites of a SMBH.

Such parameters as galaxy size or its central SMBH's mass can have false values: these data were given from open sources or even arbitrary values used (like 100,000 light-years, 100,000,000 mass of the Sun). But to restore shapes of spiral arms these values are not important: the result always can be re-scaled when more reliable values will be given. In such cases calculated values will change such as the large semi-axis of a satellite orbit or its distance to a central SMBH in a pericenter of the orbit.

Also, the program cannot guarantee that the result is absolutely exact: while modeling spiral arms all the parameter values were roughen up to ceil values of degrees, light years, years or to four decimal signs for the eccentricity parameter. But even such coarse values of parameters in most cases were enough to demonstrate the undoubted similarity modeled shapes to spiral arms of real existing galaxies.

Ring-shaped galaxies

In ring-shaped galaxies the ring part was formed by plasma emitted for a relatively small time on the shortest (nearest to SMBH) part of a satellite orbit. Whereas the bridge was shaped while the satellite was traveling far from the SMBH on its orbit. But still the difference between speed of the plasma emitted near the SMBH and far from it is not big for such satellites, shapes of bridges are not very distorted and these looks like small connections between ring turns.

The galaxy LEDA 1313424 Bullseye is a good sample of a ring-shaped galaxy, it contains at least four satellites forming its rings. Still its orbits' ecliptic planes are almost matching to each other this gives an effect of a lot of concentric rings. But some differences are there.

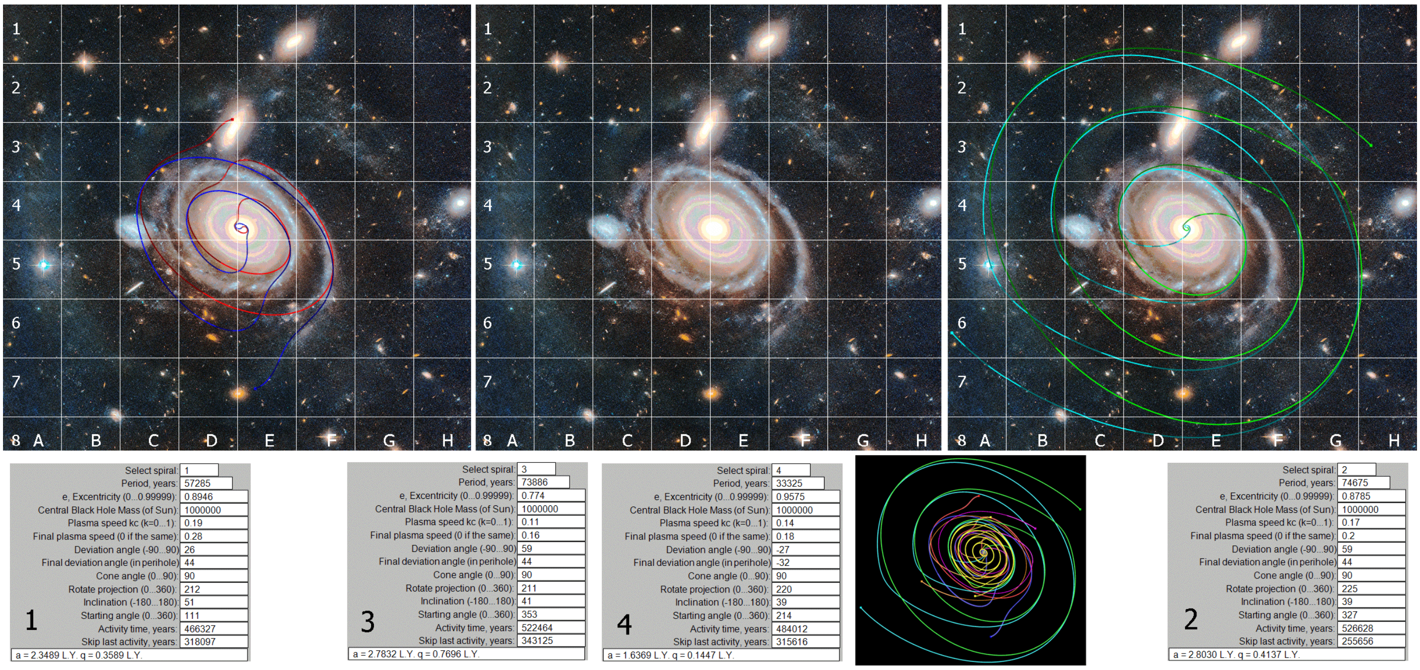

Figure 3. A model of the galaxy LEDA 1313424 Bullsyey. Satellites 1 and 2, together with parameters of satellites 3 and 4 represented below.

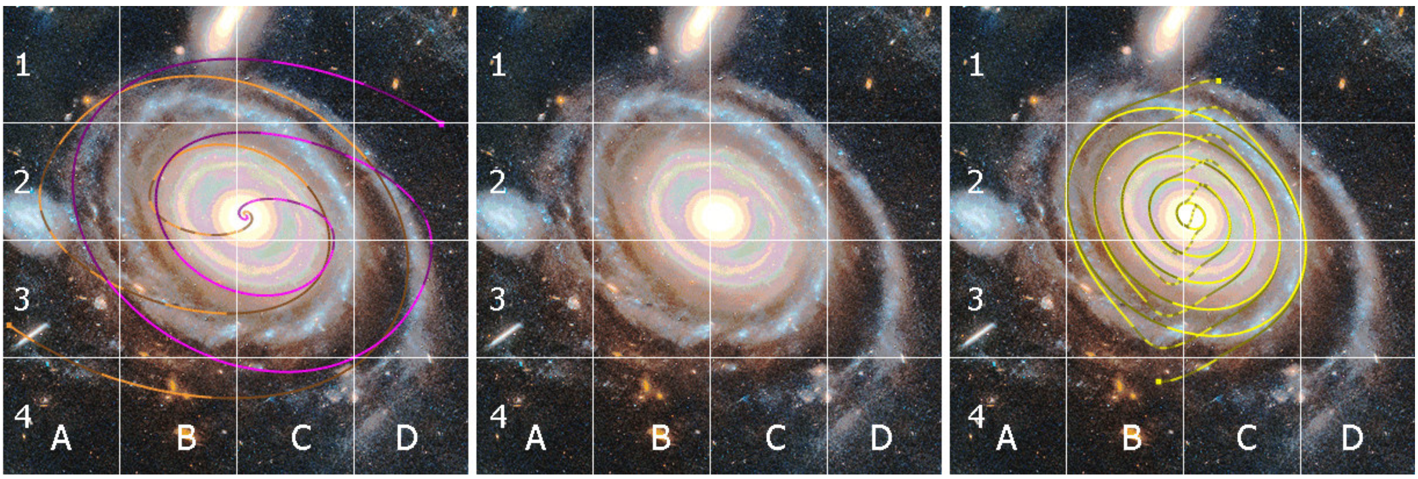

Figure 4. A model of the galaxy LEDA 1313424 Bullsyey. Satellites 3 and 4.

The main anchors while restoring satellite's orbits were not its rings but lines of bridges between them. It is important that these are symmetric and this was confirmed by models. In comparisons above photographs were additionally processed to make spiral arms lightened. The grid was not overlaid on top of an image. Instead the resulting image was split on squares which were moved apart for a pixel from each other. So there were no losses in the image or artifacts for the grid. In most of spirals (except the 4th) their own colors are used for each spiral arm. And about each 10,000 years the brightness of a line is changing. This helps to see which parts of arms were formed for longer or shorter time.

Plane eccentric galaxies

Let's look at the galaxy M51 Whirlpool as a sample of a plane eccentric galaxy. And three from its restored SMBH's satellites have suitable parameters (though it satellite no. 2 has very low eccentricity as an exception). Certainly there should be much more satellites of the SMBH in this galaxy but these four are forming the most reliable spirals.

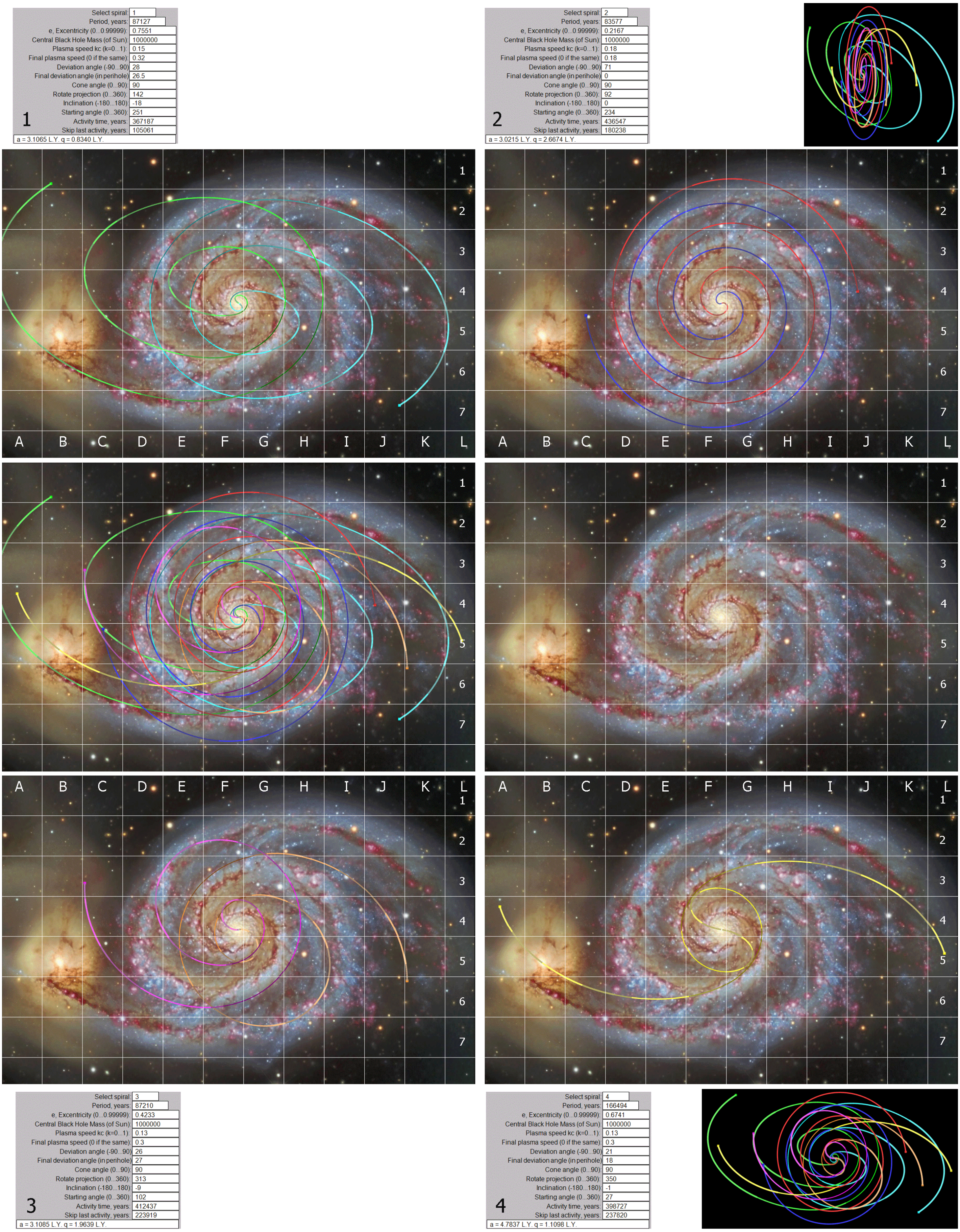

Figure 5. A model of the galaxy M51 Whirlpool. There is a view onto the model from its right side at the top right corner. An entire 4 spirals view is at the bottom right corner.

There are two plane eccentric spirals here (satellites 1 and 3). And a ring-shaped spiral is also present (satellite 4), in stage of forming an inner ring but with already dissipated outer ring. And there is a rare case here – a satellite 2 with a circle orbit (witch eccentricity value is near zero). On an example of the M51 galaxy Whirlpool we can conclude that an SMBH of a galaxy can have several satellites with different types of orbits (though all 4 satellites found in M51 have plane orbits, without a cone precession).

A model of the galaxy M31 Andromeda

While modeling spirals of the Andromeda galaxy a composite photography made by space telescopes Herschel, Planck, IRAS and COBE was used to compare with. Some filters were applied to the photography to make bounds between areas with different brightness more contrast. Finally more than 20 possible satellites were found. So these were separated onto several groups:

- Group Z: 5 satellites with plane spirals almost perpendicular to a view line with eccentric orbits forming correspondent plane spirals. These spirals are mostly defining an exterior of the M51 galaxy in optical, infrared and ultraviolet ranges.
- Group Y: 3 satellites with a small eccentricity of their ring-shaped plane spirals tilted to view at very acute angles.
- A separate single satellite YZ (or Z6): it has an eccentric orbit forming a plane elongated spiral like satellites of group Z. But it is therefore is inclined a lot to us like satellites from group Y.
- Group X: 7 satellites having a thing precession cone (below 30 degrees). These are sorted by its approximate direction of cones in a clockwise direction.
- Group W: 5 satellites with medium and large precession cone (30 degrees and higher). These satellites are not differentiating easy and suspiciously very similar by some parameters. It is possible that there is a re-inspection is required for them.

Satellites in groups Y and Z are sorted by a rotation period. The period can be refined when more exact data will be obtained on a SMBH mass and a size of a M31 galaxy. For this moment it is supposed that the mass of the SMBH in M31 is about 9.68 million masses of out Sun and the size of M31 is about 160,000 of light-years.

The galaxy M31 Andromeda. Satellites of the group Z.

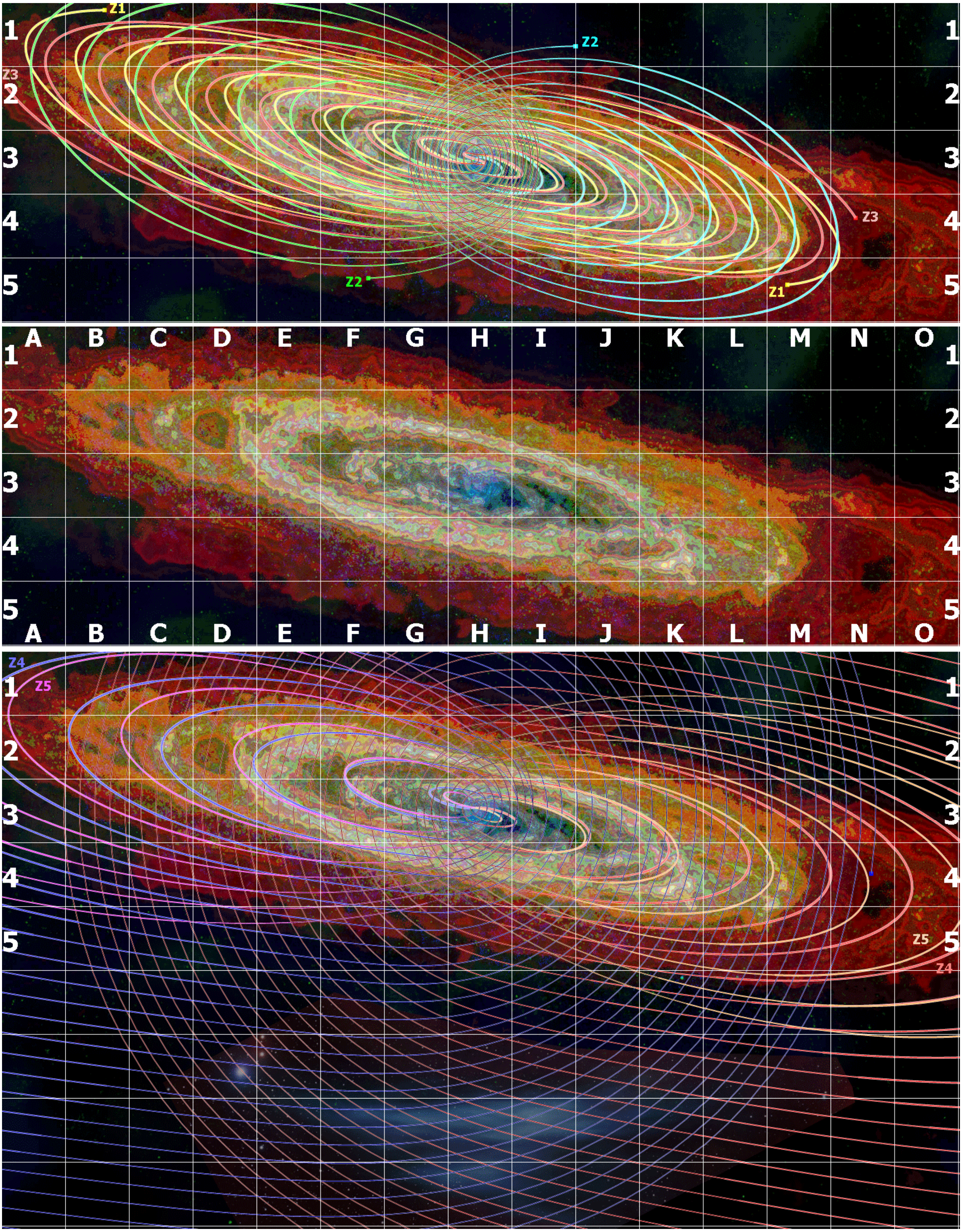

Figure 6.A model of a galaxy Andromeda. Satellites Z1–Z3 on top), Z4, Z5 (on bottom).

The Oxygen Clouds were added at the bottom part of the image opened recently by astrophotographers Marcel Drexler and Xavier Trottner [13]. It is possible that the combining is not very exact but anyway it is seen that lines of spirals Z3 and Z4 are very close to dark lines on these clouds (only Z4 spiral is elongated to it on the image).

Central ring parts of spiral arms are the result of an interaction of streams of slower plasma which are forming fast. So these are less visible against the background of more bright elements formed by more speedy particles. Therefore the central area formed as a union of the starting turns of all the Z1–Z5 spirals is clearly visible.

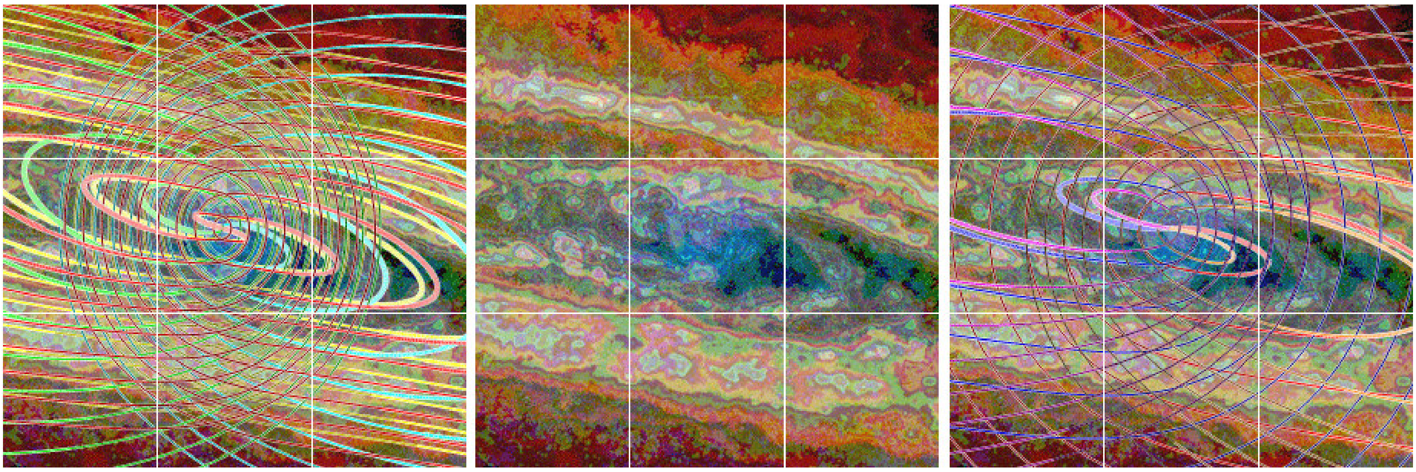

Figure 7. A model of the Andromeda. The central area. Spirals of satellites Z1–Z5.

The galaxy M31 Andromeda. Satellites of the group Y.

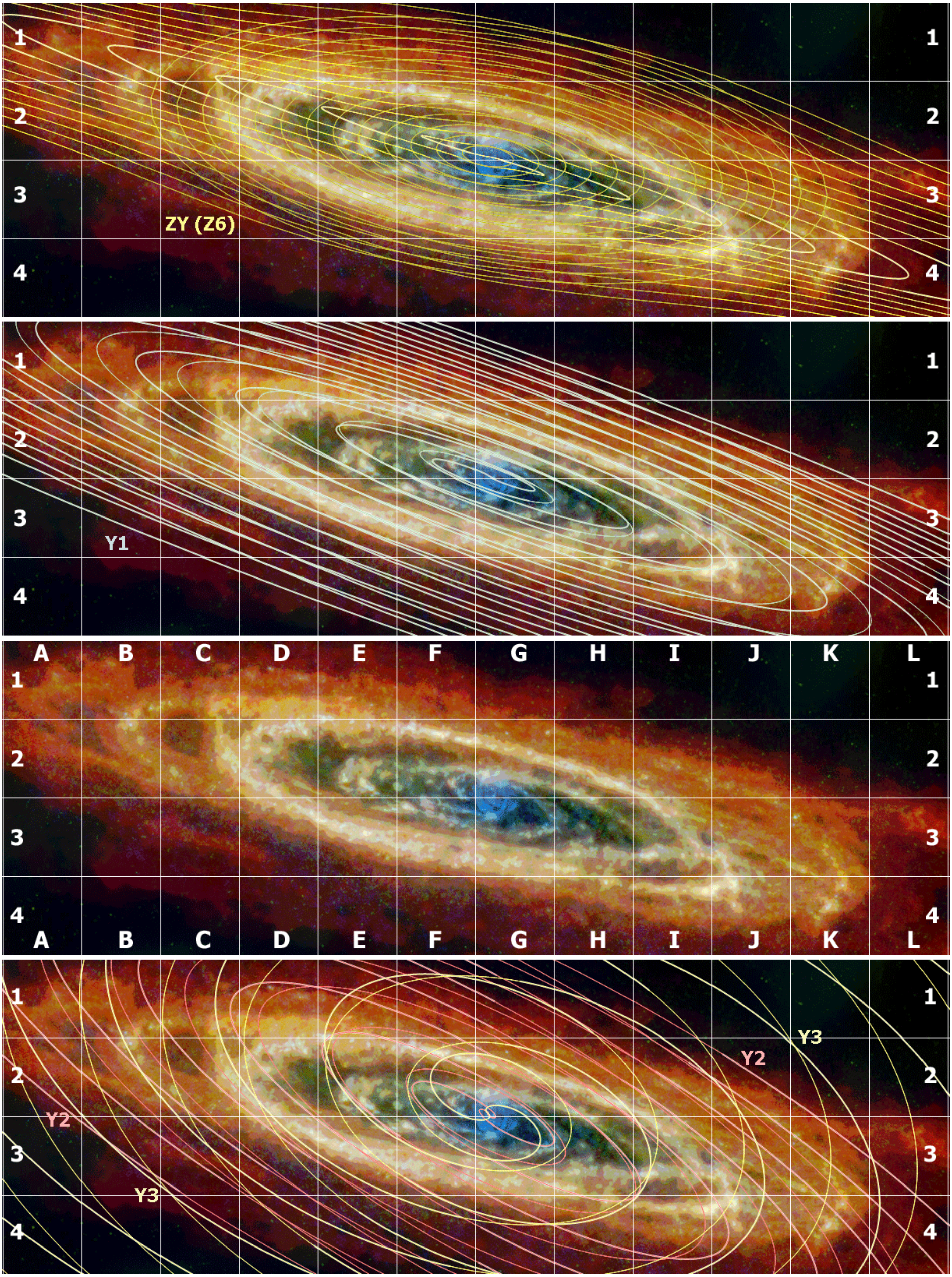

Figure 8. A model of the Andromeda. Satellites (from top to bottom): ZY (Z6), Y1, Y2 and Y3 (together).

Table 1. Parameters of the plain satellites of the SMBH of the Andromeda galaxy (of groups Z and Y).

Parameter \ Satellite	Z1	Z2	Z3	Z4	Z5	ZY (Z6)	Y1	Y2	Y3
Period	41846	42598	43556.04	49596	64453	43547	50455	50813	53464
e (eccentricity)	0.9518	0.8689	0.9462	0.9352	0.9308	0.9781	0.5848	0.5848	0.3465
v1 (of the speed of light)	0.04	0.04	0.04	0.06	0.02	0.06	0.15	0.14	0.14
v2 (of the speed of light)	0.26	0.26	0.26	0.35	0.28	0.25	0.19	0.18	0.19
d1 (initial deviation)	63	63	63	48	61	63	66	66	66
d2 (final deviation angle)	57	57	57	48	61	57	70	70	70
Projection rotation	265.4	264	264	256	291	9	20	28	20
Ecliptic plane inclination	25	24	25	12	18	69	99	109	53
Starting angle	164	164	164	161	141	75	61	61	75
a (light-years)	4.0604	4.1089	4.1703	4.5474	5.4154	4.1697	4.5998	4.6215	4.7809
q (light-years)	0.1641	0.4464	0.1832	0.2207	0.2357	0.0746	1.4139	1.4139	2.2254

The galaxy M31 Andromeda. Satellites of the group X.

There are at least 7 thin-conical double spirals intersecting its plane by its formative cones.

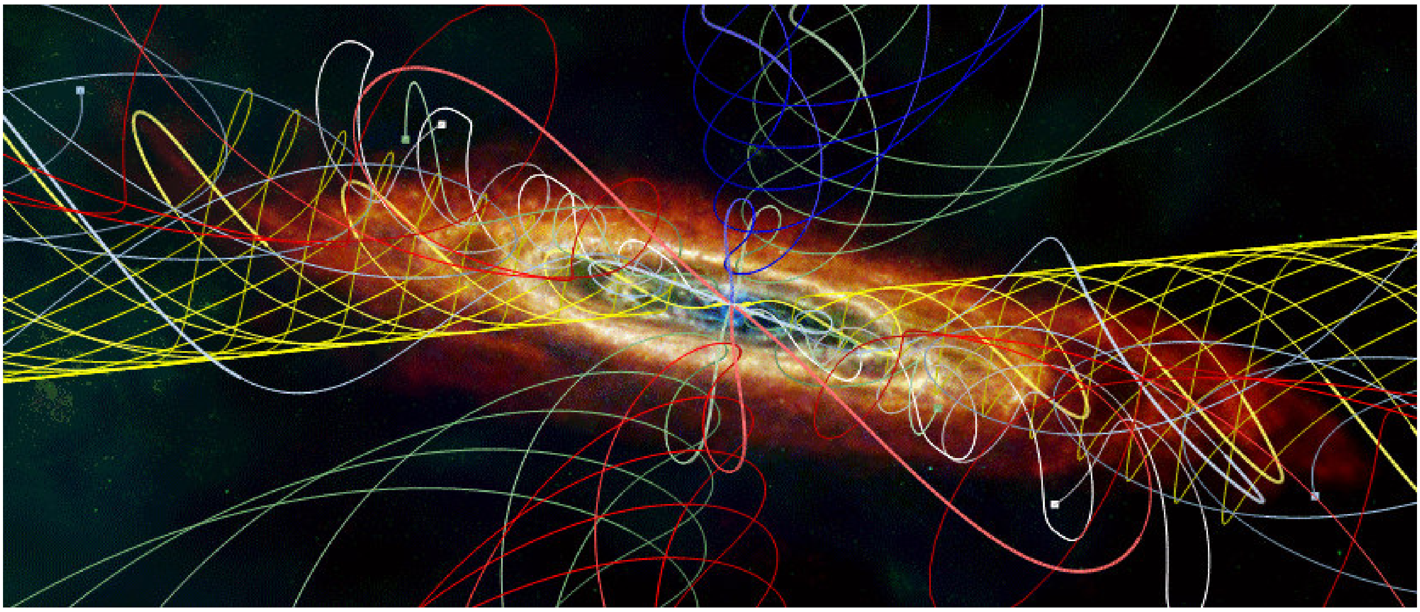

Figure 9. A model of the Andromeda. Spirals of satellites X1–X7.

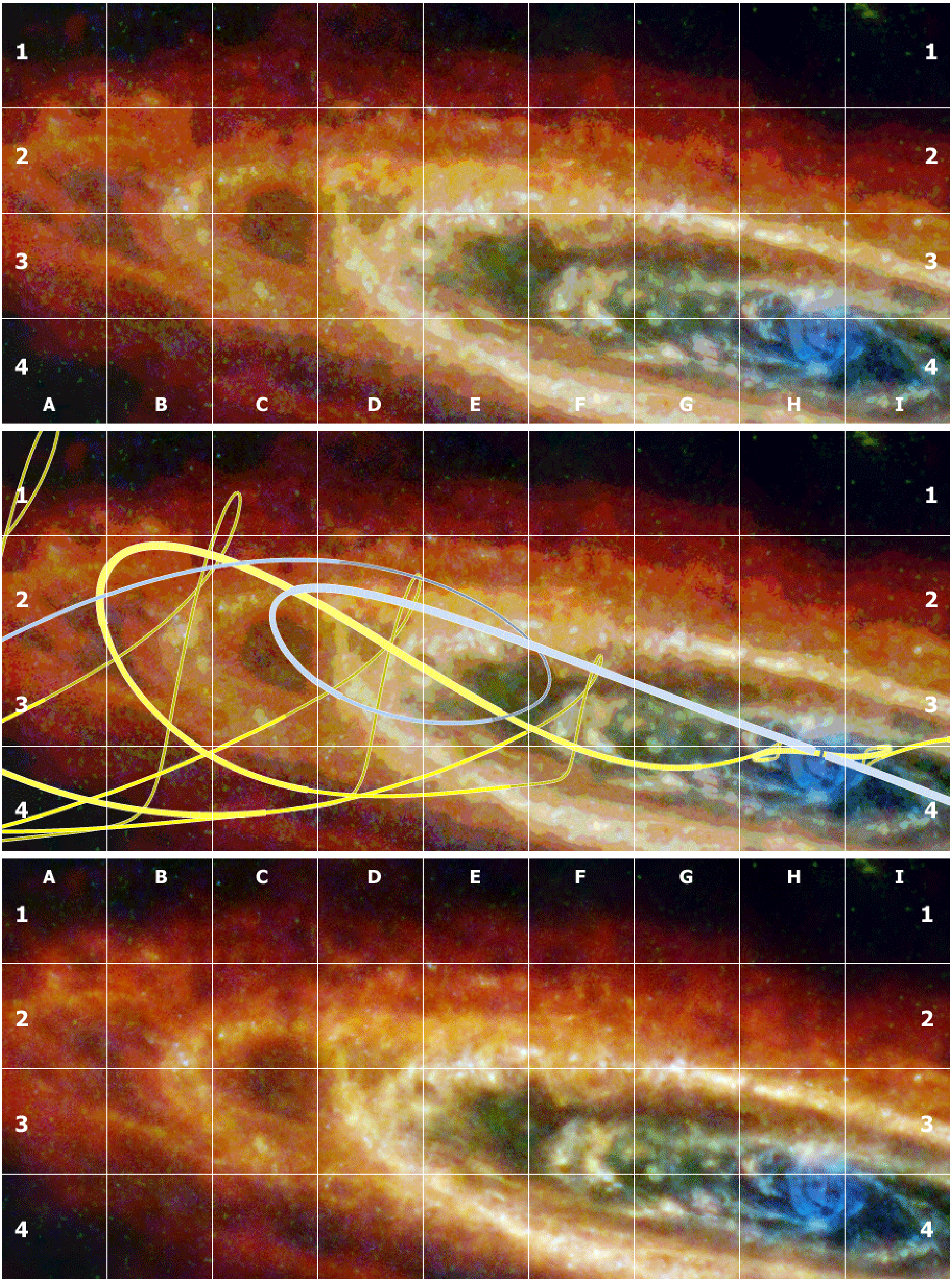

Figure 10. A model of the Andromeda. Satellites X1 and X2 (left center part). A clear photography with post-processing is on top, and a clear photography without the post-processing on bottom.

The spirals X1 and X2 are forming a “mysterious” loop, sufficiently distorting an exterior of the first big ring of the Andromeda (left to the center on the image). There is a symmetric formation existing at the right side but it is located behind the main disk of the galaxy and less visible.

Table 2. Parameters of the plain satellites of the SMBH of the Andromeda galaxy (of group X).

Parameter \ Satellite	X1	X2	X3	X4	X5	X6	X7
Period	82231	175362	125510	207785	129831	153193	153193
e (eccentricity)	0.9769	0.4413	0.9052	0.9955	0.9133	0.7028	0.6546
v1 (of the speed of light)	0.09	0.09	0.09	0.09	0.09	0.09	0.09
v2 (of the speed of light)	0.38	0.4	0.15	0.4	0.29	0.38	0.38
d1 (initial deviation)	89	89	57	57	59	89	89
d2 (final deviation angle)	-94	-94	-164	-95	-98	-94	-94
Precession cone angle	15	16	9	21	10	12	13
Projection rotation	99	96	113	122	125	18	37
Ecliptic plane inclination	-84	-116	-48	-60	-146	-154	-154
Starting angle	33	36	19	26	351	252	252
a (light-years)	6.3703	10.5542	8.4448	11.8180	8.6375	9.6448	9.6448
q (light-years)	0.0787	1.9026	0.3228	0.0153	0.2952	1.0121	1.1762

The galaxy M31 Andromeda. Satellites of the group W.

The last group W contains satellites with medium and wide precession code. It is possible that there are more of such satellites but only some most notable by traces found on the background of the main spiral pattern on the photography.

Table 3. Parameters of the plain satellites of the SMBH of the Andromeda galaxy (of group W).

Parameter \ Satellite	W1	W2	W3	W4	W5
Period	152341	150642	78011	189455	156248
e (eccentricity)	0.9504	0.3656	0.0064	0.2254	0.0417
v1 (of the speed of light)	0.09	0.09	0.09	0.09	0.09
v2 (of the speed of light)	0.38	0.38	0.38	0.38	0.3
d1 (initial deviation)	89	89	89	89	89
d2 (final deviation angle)	-94	-94	-94	-94	-94
Precession cone angle	30	56	56	68	68
Projection rotation	85	140	127	68	79
Ecliptic plane inclination	-179	-192	-233	-236.4	119
Starting angle	263	266	266	263	264
a (light-years)	9.6090	9.5374	6.1504	11.1123	9.7726
q (light-years)	0.1689	2.1604	3.3836	2.6378	3.2634

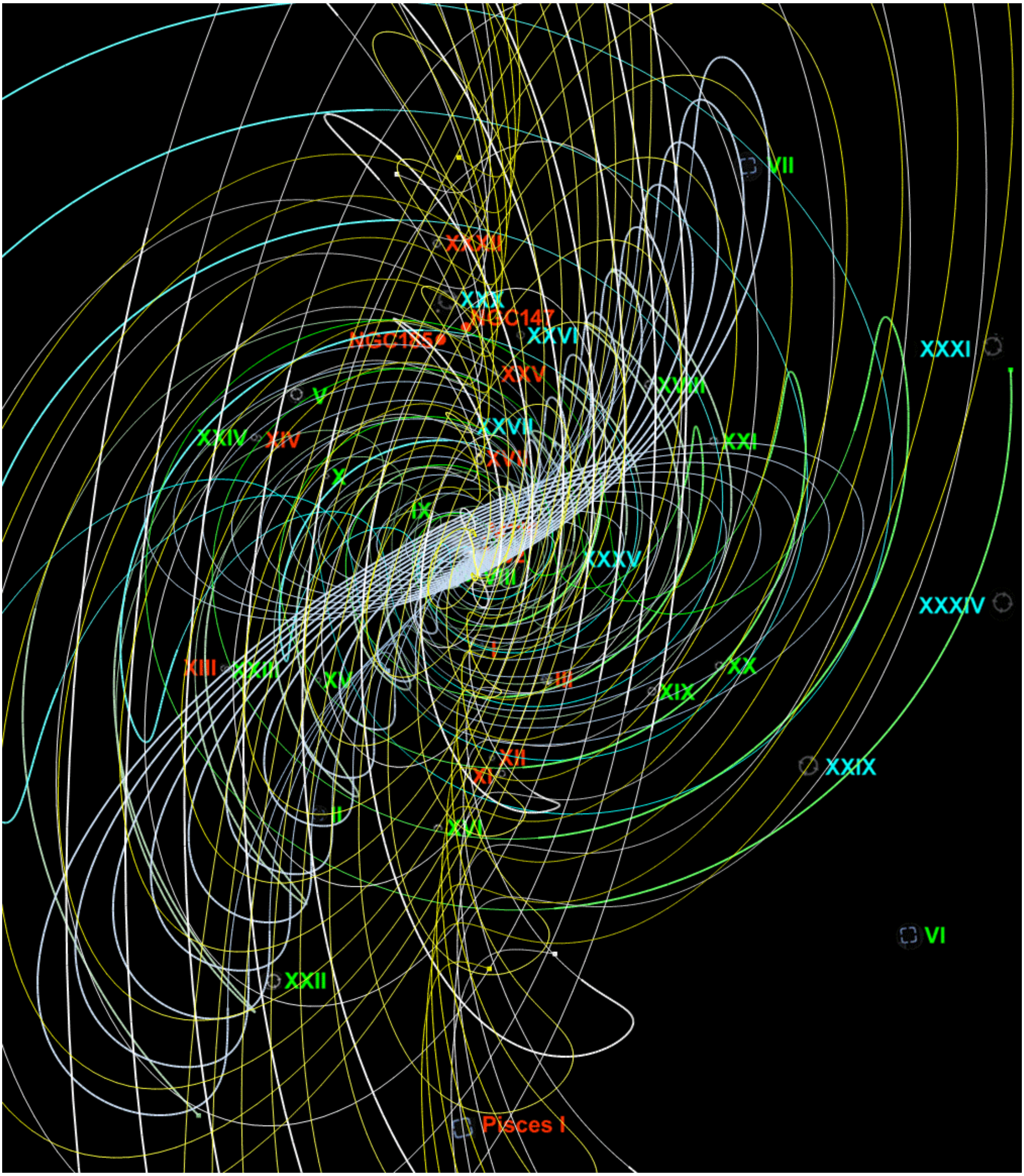

Figure 11. A model of the Andromeda. Spirals of satellites of the SMBH of the Andromeda in group W together with a fleet of dwarf galaxies – satellites of the Andromeda.

This combining can make think that a solution of two most mysterious secrets of dwarf satellites of the Andromeda is simple. These are visible because they are highlighted by the streams of plasma emitted from the M31 core. In result we can only see such of them which are located from our side (i.e. between M31 and Milky Way). And a half of them are located on the plane intersecting the center of the M31 not accidentally but because such "plane" is just a part of cone surface where one of SMBH's satellites of the M31 is forming its spiral of plasma.

Other conical galaxies

Obviously, there are some conical galaxies which are viewing from its "equator", and we should see in such case a (double) cone. It is very probably that such objects already known but these are not identified as galaxies.

For example, a planetary nebula NGC 2440 has not only spiral structures in its shape but these are satisfying the rules of forming spiral arms by plasma streams emitted from satellites of SMBH each of which is moving around it in an elliptic orbit. And this proves us that the NGC 2440 is a galaxy. And it contains two cone spirals with angles about 90 degrees at a top almost perpendicular to each other in space. One of them is seen from an equator and another – from the pole. I.e. this galaxy is very unique in comparison with others and it occupies some volume in space, not a plane.

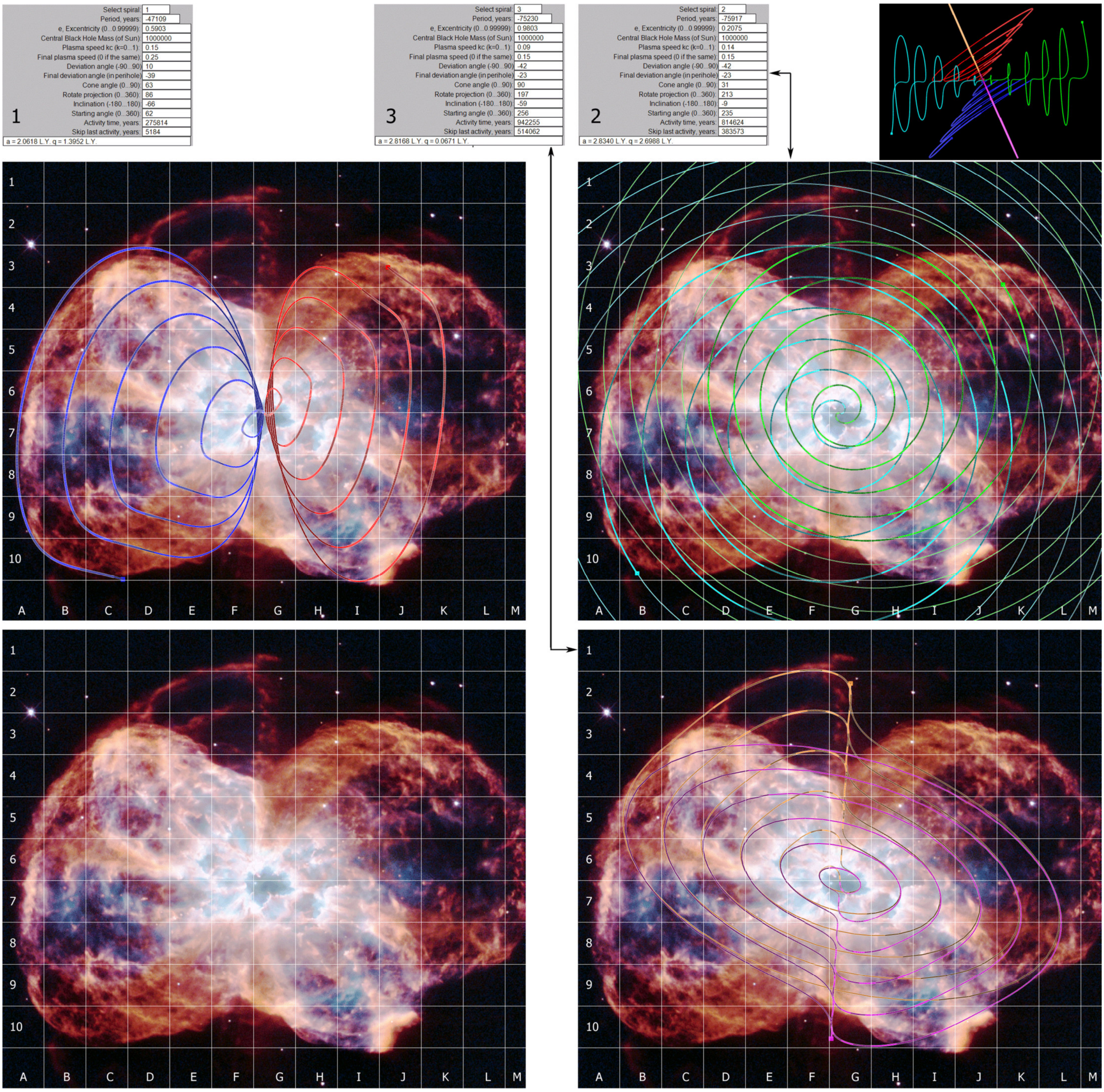

Figure 12. A model of the galaxy NGC 2440. The first free satellites' spirals. A view to the model from the top side is placed in the top right corner.

Galaxies are bigger than their spiral arms

While restoring spiral arms of the Large Magellanic Cloud there was found that if to continue spiral arms further into space than at least one of such arms could with some probability visit a supernova remnant.

This is a so called radio-ring ORC J0624-6948 [12], which is supposing to be a remnant of the first intergalactic supernova flared “recently”.

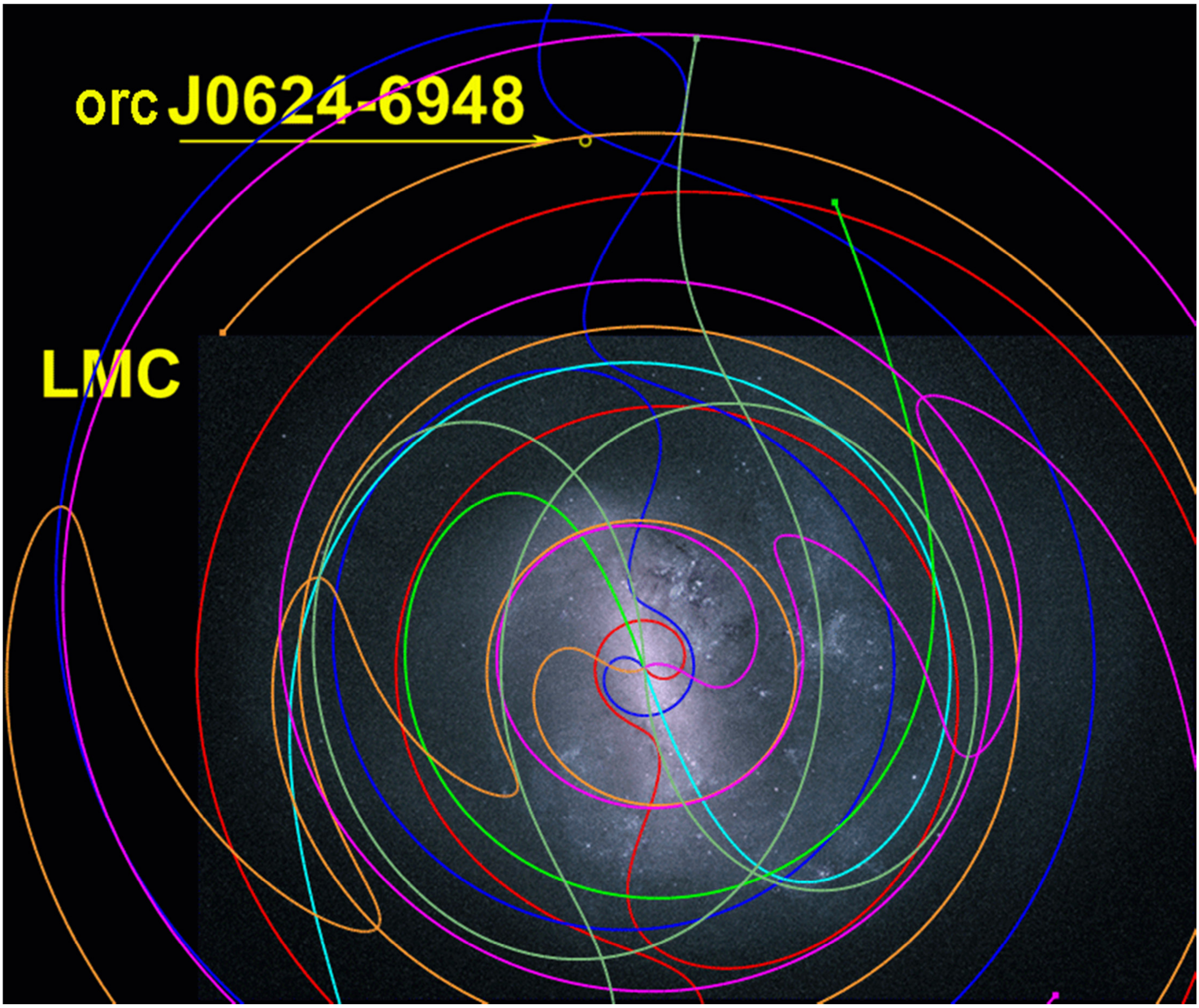

Figure 13. A model of the Large Magellanic Cloud and possible plasma influence onto the supernova OCR J0624-6948.

Intergalactic supernovae are very rare. Supernovae in other galaxies found mainly in its spiral arms. The inevitable question arises about a possible relation between supernovae flares and direct impact of plasma from galactic cores onto stars.

Practical results

So, following results were obtained.

It is shown that spiral arms of spiral galaxies are formed in a correspondence with the hypothesis suggested. Consequently, spiral arms are the results of emitting of the plasma streams from galactic cores. These streams are formed because of a gravitational interaction between SMBH and its satellites moving around it on elliptic orbits (and having very fast rotation speed around its own rotation axis – spin).

The plasma is emitted not always in the same plane. If the axis of the own rotation of the SMBH’s satellite is tilted to its ecliptic plane and it is precessing while moving around the SMBH, then the plasma streams forming spirals not on a plane but along a correspondent double cone in space.

The speed of plasma emitted depends on a distance between a satellite and a SMBH (and from its masses too, probably). When a satellite approaches a SMBH then the speed of emitting of plasma is decreasing and contrary it is maximized at the apocenter position. This dependency is linear (or almost linear).

A deviation angle of a straight line along which plasma is emitting from a line connecting a satellite and SMBH also can vary while moving the satellite around the SMBH. And this dependency also is linear.

A time of forming one turn of a spiral arm corresponds to one turn of a satellite around a SMBH and it can endure several thousands (or tenths of thousands) years – for spirals which can be identified easy on photographs. A SMBH usually has several satellites but not all of them generate enough power streams of particles to provide well visible spiral arms in a galaxy.

On some distance from galaxy cores the plasma density is decreases and its influence onto gas and dust in a galaxy also is reduced, so glow of spiral arms went away. But this does not mean that the plasma is dismissed in space on such distance. It continues paving the way in galaxy's matter and even it cannot already burn the gas, it therefore can push it apart.

And even when the particles of the plasma leave its home galaxy, these continue moving in space infinitively with a constant speed and direction. And all the sum of such particles become an essential part of the cosmic radiation.

Also, preliminary models were obtained for some of galaxies. Among them, characteristics of more than 20 satellites' parameters were deducted for SMBH of the M31 Andromeda galaxy.

Conclusions

Finally, the suggesting model has shown its applicability to build models of spiral arms of real galaxies. So it can be considered proven on a practice the hypothesis of forming of spiral arms of galaxies as a result of a single physical phenomenon which is an emission of two opposite directed streams of high-energy streams of particles from a galaxy core. More exactly, from the satellites of a SMBH.

This model does not require billions of years to form spiral arms of spiral galaxies [1], it is enough to have tenths or hundreds of thousands years. This model will definitely serve to astronomers as a tool to learn structures of galaxies, its cores, star-formation processes, flares of supernovae etc.

At least one problem can be considered resolved: the problem of "solid rotating of galaxies", is a dark matter responsible for a difference between an expected and actual speed of rotating a matter in spiral galaxies or something else? ([11]). Answer is: something else. And be more precise, it is most probably that a speed of not a rotation of a matter was measured but a speed of moving a gas after an impact with plasma streams from galaxy core. And still plasma speed is the same on any distance from a galaxy center the resulting speed of a gas was not changing a lot. And this led to "strange" results.

Possible applications of the emission model are following.

- Researching structures of cores of galaxies and galaxies themselves;
- Clarification distances to objects.
- Getting information about speeds of galaxies and objects in them.
- Researching the structure of the Milky Way (restoring a structure, prediction a time approximation of next streams passing over surrounding of the Sun etc).
- And so on, and so forth.

In any case, great thanks to all of the astronomers for their hard and often not thankless work. And a special thanks to people, teams, organizations and governments, which could find funds, time and forces and to launch in space powerful space telescopes. Which photographs was shown us so incredible beauties of space. Also thanks to makers of personal computers, operating systems and powerful graphical and office applications which made this work possible.

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