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Short Communication

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On the Question of the Relation of the Masses of the Galaxies and their Central Black Holes

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Abstract

The article touches upon the relations of some parameters (mass, radius) of the central supermassive Black Holes (SMBH) and parent galaxies. The definite patterns of these relations are revealed which apparently played an important role in the process of the formation and evolution of galaxies. Most likely, galaxies and their central black holes have common and joint origin and their physical characteristics are always mutually conditioned.

Keywords: Galaxy, Supermassive Black Holes, Radius of Gravitational Capture (Radius Bondi), Gravitational Radius

1. Introduction

The observation of the last decades showed that at the center of many galaxies there are supermassive black holes (SMBH) [1]. In order to study their role and meaning in the formation and evolution of the mother galaxies it is important to compare and determine the dependence and relation of some of their physical features. And, first of all, relation of their masses [2]. Radius Bondi, according to the definition, is $R_B \sim \frac{G \cdot M_{BH} \cdot m_p}{kT}$, where T is the temperature of the interstellar medium. Supposing that the temperature of the interstellar medium is equal to the virial temperature of the galaxy (which occurs frequently), it can be found that $\frac{kT}{m_p} \sim \sigma^2$, where σ is the dispersion of the galaxy speed. On the other hand, the typical radius of the galaxy can be estimated according to the theory of the virial as $R_G \sim \frac{GM_G}{\sigma^2}$.

Hence, $\frac{M_G}{R_G} \sim \frac{M_{BH}}{R_B}$.

This relation, apparently, is the main cosmogonist law which as we think is equally true for all morphological types of ga-laxies.

$$\frac{M_G}{M_{BH}} = \frac{R_G}{R_B} \text{ or } \frac{M_G}{R_G} = \frac{M_{BH}}{R_B}$$

It cannot be a simple coincidence as scientists found some correlations between masses of galaxies /their halo/ and the central black hole long ago.

From the analysis of the observed data it logically follows that the mass of the central SMBH cannot exceed the mass of the mother galaxy but can neither be less than $-\frac{MG}{105}$ i.e. the mass of the central SMBH is limited from above and below, $10^5 \geq MG/m_{BH} \geq 1$.

2. The numeric value of the parameters MG and RG, the masses and radiuses of galaxies in Messier objects are rather clarified by different methods of observations. [3] The comparison and analysis of those data reveal a definite pattern, the correlation of the RG – radiuses of galaxies to the corresponding gravitational radiuses Rg (G) by order of magnitude is equal to -10^5, i.e. $RG/R_g(G) = 10^5$ or $R_G = Rg(G) \cdot 10^5$. In the chart 1 it is shown the numeric value of the parameters MG and RG of some of the Messier galaxies where there are given also the values of the corresponding gravitational radiuses, counted according to Schwarzschild $Rg_{(G)} = \frac{2G.MG}{C2}$ as well as the relation of $R_G / R_g(G)$.

From the examples brought in the chart 1 it is evident that the revealed pattern is common to all morpho-logical types of galaxies, and some possible exceptions from that law are results of defects or miscounting of some circumstances, as well as a result of the ambiguity of the numeric multiplier of the dimensionless quantity 10^5.

Chart 1.

Name	M_G in grams	R_G in centimetres	$R_{g(G)}$ in centimetres	$\frac{R_G}{R_{g(G)}}$
M31	$1{,}3.10^{45}$	10^{23}	2.10^{17}	10^5
M32	6.10^{42}	$3{,}6.10^{21}$	7.10^{15}	10^5
M33	6.10^{43}	$2{,}7.10^{22}$	10^{16}	10^5
M49	4.10^{44}	7.10^{22}	6.10^{16}	10^5
M58	6.10^{44}	$4{,}8.10^{22}$	10^{17}	10^5
M61	$1{,}4.10^{44}$	$4{,}2.10^{22}$	10^{17}	10^5
M63	$2{,}8.10^{44}$	$4{,}5.10^{22}$	10^{17}	10^5
M74	6.10^{44}	3.10^{22}	10^{17}	10^5
M77	2.10^{44}	$4{,}5.10^{22}$	10^{17}	10^5
M81	10^{44}	$4{,}2.10^{22}$	10^{17}	10^5
M82	10^{44}	$1{,}6.10^{22}$	10^{17}	10^5
M85	8.10^{44}	$4{,}5.10^{22}$	10^{17}	10^5
M87	$5{,}4.10^{45}$	$6{,}3.10^{22}$	6.10^{17}	10^5
M88	5.10^{44}	$3{,}5.10^{22}$	10^{17}	10^5
-M94	$1{,}2.10^{44}$	$2{,}2.10^{22}$	10^{17}	10^5
M95	10^{44}	$4{,}8.10^{22}$	10^{17}	10^5
M96	$1{,}6.10^{44}$	5.10^{22}	10^{17}	10^5
M98	4.10^{44}	$5{,}8.10^{22}$	10^{17}	10^5
M99	2.10^{44}	$5{,}2.10^{22}$	10^{17}	10^5
M100	4.10^{44}	$5{,}8.10^{22}$	10^{17}	10^5
M104	6.10^{44}	$6{,}2.10^{22}$	10^{17}	10^5
M105	2.10^{44}	$2{,}2.10^{22}$	10^{17}	10^5
M109	5.10^{44}	6.10^{22}	10^{17}	10^5
Large Magellanic Cloud	2.10^{43}	$6{,}3.10^{21}$	10^{16}	10^5
Small Magellanic Cloud	10^{43}	6.10^{21}	10^{16}	10^5
Milky Way	96.10^{44},	4.10_{22}	10^{17}	10^5
M110	10^{43}	$7{,}2.10^{21}$	10^{16}	10^5

3. As the aim of this article is the revelation of the relation of the galaxies and central SMBH, then, first of all, it is necessary to find and/or clarify the numeric value of the whole masses of those galaxies from Messier objects whose central black holes are revealed by observations.

For this reason, let us use the equation of $R_G = \frac{R_{g(G)}}{10^5}$ and $M_G = \frac{c^2 \cdot R_{g(G)}}{2G}$. In chart 2, the results of the

Counting are Given

Chart 2

Galaxies		R_G	M_G	$R\,g_{(G)}$
M 59	NGC 4621	3,4 · 10_{22} cm	6 · 10_{gr44}	3,4 · 10_{17}cm
M 60	NGC 4649	5,1 · 10_{22} cm	1.3 · 10_{gr45}	5,1 · 10_{17}cm
M 84	NGC 4374	5 · 10_{22} cm	10_{gr45}	5 · 10_{17}cm
M 89	NGC 4552	3,3 · 10_{22} cm	6 · 10_{gr44}	3,3 · 10_{17}cm
M 106	NGC 4258	6,3 · 10_{22} cm	2 · 10_{gr45}	6,3 · 10_{17}cm

4. During the last 2 decades, through observations there have been revealed the radiuses of gravitational capture (radius Bondi) of SMBH in some galaxies. The central black hole in the galaxy M106 has a mass of MBH = 7,2 · 10gr40 and the radius of the gravitational action was identified by observations R_B≈10cm18. The sphere of the gravitational impact of the SMBH galaxy NGC1332 is limited by the radius − RB =7,2 · 10cm19, the mass of the black hole is equal to MBH =1,3 ·10gr42 and Schwarzschild's radius Rg =2 · 10cm14. [4] The radius Bondi of the central SMBH of galaxy is clarified by observations, NGC3115 − RB = 10cm20, and the mass is MBH =1,8 ·10cm42.[5] It follows from the examples that the radiuses of the gravitational capture (RB – radius Bondi) of central SMBH too by order of magnitude is 105 times more than the gravitational radiuses of the corresponding SMBH, i.e. $RB = RG$ · 105 or $RBRg$. This sequence is, to my mind, true for the galaxies of all morphological types which can always be checked by observations, which was first done by academician R. A. Syunyaev with his coworkers. Studying the elliptical galaxy M87, they determined the gravitational radius of SMBH − RBH = 10cm15, and the relation of radius Bondi to the gravitational radius of SMBH as $RBRg$ ~(ccs)2~ 105, where is the speed of light and sc is the speed of sound [6].

5. After finding out the above mentioned patterns, we can imagine the law found out by us, the law of the relations of the whole masses of galaxies and masses of their SMBH. $MG\ MBH = RG\ RB$ or $MG\ RG = MBH\ RB$. The last equations were revealed in this way: using the famous equation of Schwarzschild, the relations of the masses of galaxies and their SMBH to the corresponding gravitational radiuses were presented in the form of the equation, $MG\ RG$(i) = $MBH\ Rg = c22G$, then all the three components of the given equation are divided on the same number - 105 and it is equal to $MG\ Rg(G)$ · 105 = $MBH\ Rg$· 105 = $c22G$· 105 and as we found out that − $RG = Rg(G)$· 105, then the equation can be rewritten in a new form $MG\ RG$ = $MBH\ RB$ = $c22G$ · 105 = $const.$

Chart - 3

Galaxies	MG	RG	MBH	RB	**$MG\ RG$=$MBH\ RB$ = $c22G$ · 105 =$const.$ ≈ 1022**
Milky Way	9,6·1044	4·1022	8·1039	10^{17}	10^{22}
M31	7·1044	7·1022	6,6·1040	10^{18}	10^{22}
M32	6·1042	3·1021	7,8·1039	10^{17}	10^{22}
M33	6·1043	2,7·1022	1039	10^{17}	10^{22}
M49	4·1044	7·1022	1042	10^{20}	10^{22}
M58	6·1044	4,8·1022	6·1041	10^{19}	10^{22}
M106	7·1044	6,3·1022	8·1040	10^{18}	10^{22}
M61	1,4·1044	4,2·1022	1,4·1040	10^{18}	10^{22}
M77	2·1044	4,5·1022	3,2·1040	10^{18}	10^{22}

M81	1044	4,2·1022	1,2·1041	10^{19}	10^{22}
M82	1044	1,6·1022	6·1040	10^{18}	10^{22}
M84	8·1044	4,5·1022	3,2·1042	10^{20}	10^{22}
M87	5,4·1045	6,3·1022	6,8·1042	10^{20}	10^{22}
M89	5·1044	3,5·1022	2·1042	10^{20}	10^{22}
M99	2·1044	5,2·1022	2·1041	10^{19}	10^{22}
M104	6·1044	5·1022	2·1042	10^{20}	10^{22}
M105	2·1044	2,2·1022	3·1041	10^{19}	10^{22}
M110	1043	7,2·1021	1039	10^{17}	10^{22}
NGC 4342	3,2·1044	4,2·1021	6,8·1041	10^{19}	10^{22}
NGC 4291	5·1044	7,7·1021	3·1041	10^{19}	10^{22}
NGC 2787	7,6·1043	1,2·1021	7,8·1040	10^{18}	10^{22}
NGC 3115	1,1·1044	2·1021	1,8·1042	10^{20}	10^{22}
NGC 821	4·1044	7·1021	1041	10^{19}	10^{22}
IC1101	4,8·1046	2,7·1024	8·1043	10^{21}	10^{22}
NGC 1277	6·1043		2,8·1043	10^{21}	10^{22}
NGC 4889	2,4·1046	3,5·1022	4,2·1043	10^{21}	10^{22}
VVCD3	9·1040		8,8·1039	10^{17}	10^{22}

6. From the analysis of the observed data, it follows that the mass of the central SMBH cannot outweigh the hole mass of the parent galaxy but neither can it be less than *MG* 105 i.e. the mass of the central SMBH is limited from above and below, $10^5 \geq$ *MG MBH* ≥ 1.

Chart 4

Chart 4 Galaxies	M_G	M_{BH}	$\boldsymbol{M_G M_{BH}}$
Milky Way	9,6·1044	8·1039	10^5
M31	10^{45}	6,6·1040	10^4
M32	6·1042	7,8·1039	10^3
M33	6·1043	1039	10^4
M49	4·1044	1042	10^2
M58	6·1044	6·1041	10^3
M106	7·1044	8·1040	10^4
M61	1,4·1044	1,4·1040	10^4
M77	2·1044	3,2·1040	10^4
M81	10^{44}	1,2·1041	10^3
M82	10^{44}	1040	10^3
M84	8·1044	3,2·1042	10^2
M87	5,4·1045	6,8·1042	10^2
M89	5·1044	1042	10^2
M99	2·1044	1041	10^3
M104	6·1044	2,2·1042	10^2
M105	2·1044	1041	10^3
M110	10^{43}	1039	10^4
NGC 4342	10^{44}	1041	10^3
NGC 4291	5·1044	3·1041	10^3
NGC 2787	7,6·1043	7,8·1040	10^3
NGC 4889	2,4·1046	4,2·1043	10^3
NGC 821	4·1044	1,2·1041	10^3
IC1101	9·1046	8·1043	10^3
NGC 1277	6·1043	2,8·1043	14%
NGC 3115	1,1·1044	1,8·1042	52
VCD3	9·1040	8,8·1039	13%
M59c0	4·1044	1043	18%

7. Conclusion

1) First of all, the mass of the central SMBH doesn't strictly depend on the mass of the parent galaxy. Dwarf galaxies have 102− 103 times less mass than the spiral galaxies as ours but their SMBH have masses 102− 103 times larger than the SMBH of spiral galaxies.

2) From the claim of the 1st point it follows that the SMBH of galaxies do not increase their mass due to swallowing the dark matter as in this case the SMBH of spiral galaxies must have larger masses because they have more dark matter than the dwarf ones…

3) Two ultimate cases of relations are revealed $MG\ MBH$: a) when the relation of $MG\ MBH$ is close to 1, the radius of the mother galaxy is equal to the radius Bondi SMBH, $RG = RB$, which possibly means that that galaxy is a newborn one and is in the initial phase of its evolution. b) When that relation is equal to 105 and $RG = RB \cdot 105$ then that galaxy is old and is in the culmination phase of its evolution, 'maturity' and stationary state.

4) It is revealed that the law $MG\ RG = MBH\ RB = c22G \cdot 105$ is true not only for all morphological types of galaxies but is characteristic of all stages of evolution of galaxies, and that means that galaxies and their central SMBH have common origin and their physical characterristics are always mutually conditioned…

Resuming the article, we come to not only the above mentioned conclusions but also to very important questions.

a. a.We revealed and described the common patterns of the type $RB = Rg(G) \cdot 105$ and $RB = Rg \cdot 105$ equations but they did not give physical explanation of these laws why it is so.

b. b.Analogically, the article does not contain a physical explanation of the law $MG\ RG = MBH\ RB = c22G \cdot 105 = const.$

c. c.It is commonly known that masses of SMBH are limited by $10G38 < MBH \leq 10G43$.
Why are SMBH with masses more than 10□43 not observed do they not exist or because of some other reasons?

d. d.What kind of genealogical connections exist between black matter and central black holes in galaxies?

e. e.Why do in all luminous astronomical bodies exist dark matter and SMBH which have a system-forming role and in stars are seemingly absent?

f. f.Physical explanation is needed also for the limitation of relation $105 \geq MGMBH \geq 1$.

We shall try to answer all these questions in the next article.

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