Possible explanations of the impossibles

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Abstract

Possible creation mechanism of "impossible" black holes.

Astronomical data of recent years strongly indicate that a significant number of observed black holes do not fit into any hypothesis about their astrophysical origin. This is true both for the contemporary and young Universe at a redshift of order 10. The contradictions with observations disappear if we accept the hypothesis that the vast majority of black holes are primordial. The proposed mechanism is supported by the agreement of the predicted mass spectrum of primordial black holes with observations as well as the discovery in our Galaxy of a considerable amount of antimatter: positrons, antinuclej, and even antistars.
Distant anti-galaxies could be identified by fluxes of neutrino versus antineutrino from (anti)supernovae explosions.

Impossibilities in cosmology

Conventional ΛCDM cosmology encounters serious difficulties during **all the history** of the universe, **impossible** to resolve in canonical ΛCDM cosmololgy **starting from our time with the universe age about 15 billion years, and back to the past down to $\sim$ 300 million years discovered recently by HST, JWST, and ALMA at high redshifts** $z \sim 10$**.**

The inconsistenies discovered earlier are reviewed in 2018: A.D. "Massive and supermassive black holes in the contemporary and early Universe and problems in cosmology and astrophysics", Phys. Usp. 61 (2018) 2, 115.

The tension that existed during all life-time of the universe between the canonical theory and observations is neatly solved if the universe is populated by primordial black holes (PBH) that **seeded** formation of cosmic structures, **according to the inverted mechanism of galaxy formation, suggested by**
A.Dolgov, J.Silk, "Baryon isocurvature fluctuations at small scale and baryonic dark matter" PRD 47 (1993) 4244 (DS).
A.Dolgov, M.Kawasaki, N.Kevlishvil (DKK), "Inhomogeneous baryogenesis, cosmic antimatter, and dark matter", Nucl. Phys. B807 (2009) 229.

Seeding of galaxy formation by PBHs

Usually it is assumed that supermassive black holes (SMBHs) observed in large galaxies, are created by matter accretion to the galactic centres.

However, the estimated time for SMBH formation is much larger than the universe age, even for the contemporary universe, with the age about 15 billion years, to say nothing of the 20 times younger universe at $z \sim 10$. It seems **impossible** to create neither SMBH, nor early galaxies in so short time, if not stimulated by some kind of seeding.

The 30 year old DS idea of seeding, but of completely different kind, was rediscovered in several recent publications, under the pressure of the Hubble Space Telescope (HST) and the James Webb Telescope (JWST) observations of the early universe at redshifts $z = 5 - 15$. However, the origin of the suggested seeds is unclear and possibly even **impossible.**

Confirmation by ''experiment''

Observational proof of DS/DKK mechanism:

• The calculated mass spectrum of PBH very well agrees with ''experiment''.
• Noticeable antimatter population of the Galaxy is anticipated and confirmed by the observations of **positrons, antinuclei, and antistars.**
• The early galaxy formation observed by HST and JWST is explained if galaxies are SEEDED by BHs, as it is also rediscovered in several papers of the last years.
• Discovery of IMBH, with $M \sim (10^3 - 10^5) M_\odot$ in dwarfs and globular clusters, necessary for "Globular Cluster **Seeding** by Primordial Black Hole Population'', AD & K. Postnov, JCAP 04 (2017) 036, e-Print: 1702.07621 [astro-ph.CO].

• **Recent observation of record power gamma burster. Possible source is star-antistar collision.**

Problems of the early universe

Serious problems, similar to those recently found by JWST, are known already for many years. HST discovered that the early universe, at $z = 6 - 7$ is too densely populated with quasars, alias SMBH, supernovae, gamma-bursters and it is very dusty. **Impossible to give birth to all these creature were in such a short time available in conventional cosmology.**
"Hubble" sees the universe up to $z = 6 - 7$, but accidentally a galaxy at $z \approx 12$ has been discovered for which both Hubble and Webb are in good agreement .

Huge BHs in small galaxies discovered in the early universe (as well as in the contemporary one). Such huge BHs in small galaxies is **impossible** to create by the accretion of matter to galactic center, since the amount of material is tiny.

All the problems are solved if the universe is populated by primordial black holes (PBH) and the astrophysical large bubbles with very high baryonic density, according to DS and DKK.

With PBHs impossible becomes possible.

BH types by formation mechanisms

1. Astrophysical black holes,
created by the collapse of a star which exhausted its nuclear fuel. The expected masses should start immediately above the neutron star mass, i.e. about $3\boldsymbol{M_\odot}$, but noticeably below $100M_\odot$. Instead we observe that the BH mass spectrum in the galaxy has maximum at $\boldsymbol{M} \approx 8\boldsymbol{M_\odot}$ with the width $\sim (1-2)\boldsymbol{M_\odot}$. The result is somewhat unexpected but an explanations in the conventional astrophysical frameworks is possible.
Recently LIGO/Virgo discovered BHs with masses close to $100M_\odot$. Their astrophysical origin was considered **impossible due to huge mass loss in the process of collapse.** To explain their formation some quite exotic mechanisms has been specially invented.

No problem if $100\boldsymbol{M_\odot}$ BH is primordial.

BH created by accretion

2. BH formed by accretion to the mass excess in the galactic center.
In any large galaxy there exists a supermassive BH (SMBH) at the center, with masses varying from a few millions $M_\odot$ (e,g, Milky Way) up to almost hundred billions $M_\odot$. **However, the conventional accretion mechanisms are not efficient enough to create such monsters during the universe life-time, $t_U \approx 14.6$ Gyr. At least 10-fold longer time is necessary,** to say nothing about SMBH in 20 times younger universe, observed in impressive numbers by HST and JWST.

Primordial Black Holes

3. Primordial black holes (PBH) created during pre-stellar epoch

The idea of the primordial black hole (PBH) i.e. of black holes which could be formed the early universe prior to star formation was first put forward by Zeldovich and Novikov: "The Hypothesis of Cores Retarded During Expansion and the Hot Cosmological Model", Astronomicheskij Zhurnal, 43 (1966) 758, Soviet Astronomy, AJ.10(4):602–603;(1967).

According to their idea, the density contrast in the early universe inside the bubble with radius equal to the cosmological horizon might accidentally happen to be large, $\delta\varrho/\varrho \approx 1$, then that piece of volume would find itself inside its gravitational radius i.e. it became a PBH, decoupled from the cosmological expansion.

Elaborated later in S. Hawking, "Gravitationally collapsed objects of **very low mass",** Mon. Not. Roy. Astron. Soc. **152**, 75 (1971).

B. J. Carr and S. W. Hawking, "Black holes in the early Universe," Mon. Not. Roy. Astron. Soc. **168**, 399 (1974).

PBHs are (usually) not accepted by astronomical establishment. Why?!

Forbidden by "law"?

BH types by masses

There is the following conventional division of black holes by their masses:
1. Supermassive black holes (SMBH): $M = (10^6 - 10^{10})M_\odot$.
2. Intermediate mass black holes (IMBH): $M = (10^2 - 10^5)M_\odot$.
3. Solar mass black holes: masses from a fraction of $M_\odot$ up to $100M_\odot$.

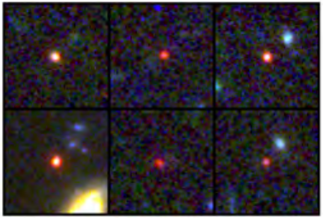
The origin of most of these BHs is unclear, except maybe of the BHs with masses of a few solar masses, which may be astrophysical.

Impossibly high observed abundance of IMBH which are appearing during last few years in huge numbers.

The assumption that (almost) all black holes in the universe are primordial strongly reduce or even eliminate the tension.

Impossible galaxies

I. Labbé, P. van Dokkum, E. Nelson, *et al*, "A population of red candidate massive galaxies 600 Myr after the Big Bang", Nature, 616, 7956, (2022), arXiv:2207.12446. Six candidate massive galaxies (stellar mass $> 10^{10}$ solar masses) at $7.4 \lesssim z \lesssim 9.1$ 500–700 Myr after the Big Bang, one galaxy with a possible stellar mass of $\sim 10^{11} M_{\odot}$, too massive to be created in so early universe. According to the authors it is **impossible** to create so well developed galaxies. **NB: "May be they are supermassive black holes of the kind never seen before. That might mean a revision of usual understanding of black holes." Well agrees with our suggestion of PBHs.**



The six candidate galaxies identified in the JWST data. (NASA, ESA, CSA, I. Labbe/Swinburne University of Technology)

Early galaxies, rich chemistry

Too high abundances of metals (elements heavier than helium).

Age of Most Distant Galaxy is confirmed with Oxygen observation.
The radio telescope array ALMA has pin-pointed the exact cosmic age of a distant JWST-identified galaxy, GHZ2/GLASS-z12, at 367 million years after the Big Bang. ALMA's deep spectroscopic observations revealed a spectral emission line associated with ionized Oxygen near the galaxy, which has been shifted in its observed frequency due to the expansion of the Universe since the line was emitted. This observation confirms that the JWST is able to look out to record distances, and **heralds a leap in our ability to understand the formation of the earliest galaxies in the Universe.**
T.J. Bakx, J.A. Zavala, I. Mitsuhashi, *et al*, "Deep ALMA redshift search of a $z \sim 12$ GLASS-JWST galaxy candidate", Monthly Notices of the Royal Astronomical Society, Volume 519, Issue 4, pp.5076-5085

Ultra-massive early QSO observed by ALMA

ALMA (Atacama Large Millimeter Array) confirmation of an obscured hyper-luminous radio-loud AGN at z = 6.853 associated with a dusty starburst in the 1.5 deg2 COSMOS field,

R. Endsley et al, "ALMA confirmation of an obscured hyperluminous radio-loud AGN at z = 6.853 associated with a dusty s tarburst in the 1.5 deg2 COSMOS field", MNRAS, 250, 4609 (2023).

VIRCam and IRAC photometry perhaps suggests that COS-87259 is an extremely massive reionization-era galaxy with $M_* = 1.7 \times 10^{11} M_\odot$

Such a very high AGN luminosity suggests that this object is powered by $\sim 1.6 \times 10^9 M_\odot$ black hole if accreting **near the Eddington limit.**

BH mass is about 1% of the stellar mass, 100 times larger than usually.

Normally impossible, but PBH could seed such monster.

Summarising: recent observations have found a large number of supermassive black holes already in place in the first few hundred million years after Big Bang. **The channels of formation and growth of these early, massive black holes are not clear, with scenarios ranging from heavy seeds to light seeds, experiencing bursts of high accretion rate.**

Rediscovery of seeding of galaxy by BH

Seeding was advocated also in A. Bogdan, A. Goulding, P. Natarajan, *et al*, "Evidence for heavy-seed origin of early supermassive black holes from a $z \approx 10$ X-ray quasar", Nature Astron. 8 (2024) 1, 126, 2305.15458 [astro-ph.GA] and A.D. Goulding, J.E. Greene, D. J. Setton, *et al*, "UNCOVER: The Growth of the First Massive Black Holes from JWST/NIRSpec—Spectroscopic Redshift Confirmation of an X-Ray Luminous AGN at $z = 10.1$", Astrophys. J. Lett. 955 (2023) 1, L24 • e-Print: 2308.02750 [astro-ph.GA].

• It was postulated that seeds of the observed early galaxies and SMBHs could be either light BH with masses $(10 - 100)M_\odot$, or heavy ones, $M = (10^4 - 10^5)M_\odot$, that might be created by **direct collapse** of gas clouds, **assuming accretion at the Edddington limit. However, the creation of the first BHs by direct collapse encounters serious problems.**

• Detection of an X-ray quasar in a gravitationally-lensed $z = 10.3$ galaxy powered by SMBH with the mass $\sim 4 \times 10^7 M_\odot$ suggests that early supermassive black holes originate from heavy seeds. The BH mass is $\sim 0.1\%$ of the host galaxy's stellar mass by far larger than in the contemporary galaxies.

Much simpler and easier if the seeds are primordial BHs.

Superfast accretion or PBH observation

It was announced in ref. H. Suh, J. Scharwächter, E.P. Farina, *et al* "Feeding Hidden Monsters: a Super-Eddington accreting Black Hole 1.5 Gyr after the Big Bang", Nature Astronomy, Advanced Online Publication,Pub Date: November 2024, arXiv:2405.05333 that the supermassive black hole LID-568 appears to be feeding on matter at a rate 40 times its Eddington limit, **theoretically imposible.** According to the authors such **impossibly huge** accretion rate is one of the possible explanations for heavy black holes formation so early in the universe. To this end some smaller black hole "seeds," are necessary which current theories suggest arise either from the death of the universe's first stars (light seeds) or the direct collapse of gas clouds (heavy seeds). The authors claim that this observation is a **discovery** that it's possible for a black hole to exceed its Eddington limit. **How could it be achieved?**

But it could be a proof of existence of supemassive PBH and no breaking of sacred principles is necessary.

Strong blow to the super-Eddington accretion

A dormant, overmassive black hole in the early Universe I. Juodzbalis, R. Maiolino, W.M. Baker, *et al*, 2403.03872: **Recent observations have found a large number of SMBHs already in place in the first few hundred million years after Big Bang. The channels of formation and growth of these early, massive black holes are not clear, with scenarios ranging from heavy seeds to light seeds experiencing bursts of high accretion rate.**
The detection, from the JADES survey, of broad Halpha emission in a galaxy at $z = 6.68$, which traces a black hole with mass of $\sim 4 \times 10^8 M_\odot$ and accreting at a rate of **only 0.02 times the Eddington limit. Sic!!!**
The black hole to stellar mass ratio is 0.4, i.e. 10^3 **times above the local relation**. It means that the galaxy is in the process of formation seeded by primordial SMBH.
According to the authors: this object is most likely the tip of the iceberg of a much larger population of dormant black holes around the epoch of reionization. Its properties are consistent with scenarios in which short bursts of **super-Eddington accretion have resulted in black hole overgrowth and massive gas expulsion from the accretion disk; in between bursts, black holes spend most of their life in a dormant(?!) state.**

Direct collapse out !? Impossible

To save direct collapse of cold gas in the early universe is necessary to assume that gas is not heated in the process of compression???!!! **Impossible.**

M.J. Hayes, J.C. Tan, R.S. Ellis, *et al* "Glimmers in the Cosmic Dawn: A Census of the Youngest Supermassive Black Holes by Photometric Variability", The Astrophysical Journal Letters, Volume 971, Issue 1, id.L16.

The variability estimate of n_{SMBH} at $z = (6-7) \geq 8 \times 10^{-3}$ Mpc^{-3} places constraints on d_{iso} to be $<<$ 100kpc. It requires the halo mass threshold for SMBH formation to be $<< 3 \times 10^{10} M_{\odot}$. However, such models begin to have more severe tension by having significantly greater abundance than the $z = 0$ estimate of n_{SMBH}.

Finally, the estimate of the necessary value of n_{SMBH} is about 100 times greater than the direct collapse prediction of Chon et al. (2016) and at least 10^4 times greater than that of Wise et al. (2019).

Confirmation of the inverted galaxy formation

The paper: M.A. Marshall, M. Yue, A-Ch. Eilers, *et al* "GA-NIFS & EIGER: A merging quasar host at $z = 7$ with an overmassive black hole", arXiv:2410.11035v2 [astro-ph.GA] 17 Oct 2024 presents a strong argument in favour of **inverted mechanism of galaxy formation,** as suggested by DS. Indeed, the measured mass of the central black hole is $M_{BH} \approx 1.4 \times 10^9 M_\odot$, that is only twice smaller than the host stellar mass equal to $M_* \approx 2.6 \times 10^9 M_\odot$. It is hard to imagine that the central BH was created by accretion of matter to the galactic center, as is commonly assumed. For comparison, the stellar mass of the Milky Way is about 60 billion solar masses and the mass of the central BH is about 5 million solar masses. **A natural conclusion is that the observed young galaxy is still in the process of formation seeded by supermassive primordial black hole.**

The authors note that the mystery of how these huge black holes grew so big so soon after the Big Bang remains unsolved - it is solved if they are primordial.

Early (impossible!) quasars in empty space

Final blow: six early quasars in empty space. Anna-Christina Eilers *et al*, "EIGER. VI. The Correlation Function, Host Halo Mass, and Duty Cycle of Luminous Quasars at $z \gtrsim 6$", the Astrophysical Journal, Volume 974, Number 2.
The data indicate that
(a) luminous quasars do not necessarily reside within the most overdense regions in the early Universe,
(b) the UV-luminous duty cycle of quasar activity at these redshifts is $f_{duty} \ll 1$.
Such short quasar activity timescales challenge our understanding of early supermassive black hole growth.
Using the James Webb Space Telescope, astronomers have peered back 13 billion years to discover **surprisingly lonely** supermassive black hole-powered quasars.
Eilers: "**Some of them seem to be sitting in the middle of nowhere**
It's difficutl **(impossible?)** to explain how these quasars could have grown so big if they appear to have nothing to feed from.
"Contrary to previous belief, we find, on average, these quasars are not necessarily in those highest-density regions of the early universe."
Possibly o.r surely they are primordial SMBH.

Huge SMBH in tiny galaxy

Madeline A. Marshall, Minghao Yue, Anna-Christina Eilers, *et al*, "GA-NIFS & EIGER: A merging quasar host at $z = 7$ with an overmassive black hole", arXiv:2410.11035 [astro-ph.GA].

The black hole powering the quasar has a record mass relative to the stars of the host galaxy. $M_{BH} \approx 1.4 \times 10^9 M_\odot$ while $M_* \approx 2.6 \times 10^9 M_\odot$ It weighs in at 54 percent of its galaxy's stellar mass, versus only about 0.1 percent for central black holes in modern giant galaxies.

Simplest explanation: SMBH is possibly primordial or it has been seeded by PBH that in turn is seeding the galaxy, that have not yet reached its final mass value.

Summary of the impossibles in the early universe

- Impossible (super) Eddington accretion.
- Impossible direct collapse.
- Impossible quasars in empty space.
- Impossible creation of supermassive BH in very young universe.

- **PBHs make the impossible possible.**

PBH and inflation

Inflation permits creation of very heavy PBH, otherwise **impossible**.
In earlier works the predicted masses of PBH were quite low.
Inflation was first applied to PBH production in DS paper: 30 years ago and a year later in: B.J. Carr, J.H. Hilbert, J.E. Lidsey, "Black hole relics and inflation: Limits on blue perturbation spectra", Phys.Rev.D 50 (1994) 4853; and soon after in P. Ivanov, P. Naselsky, I. Novikov (May 10, 1994), Inflation and primordial black holes as dark matter, PRD 50 (1994) 7173.
Presently inflationary mechanism of PBH production is commonly used. It allows to create PBH with very high masses, but the calculated mass spectra are multi-parameter and quite complicated.
The only exception is the log-normal spectrum predicted by DS and confirmed by observations:

$$\frac{dN}{dM} = \mu^2 \exp\left[-\gamma \ln^2(M/M_0)\right],$$

Theoretically calculated $M_0 = 17 M_\odot$ perfectly agrees with the data.

Impossibly light black holes

In the paper T. Jayasinghe, K.Z. Stanek, T.A. Thompson, *et al*. "A unicorn in monoceros: the $3M_\odot$ dark companion to the bright, nearby red giant V723 Mon is a non-interacting, mass-gap black hole candidate",
MNRAS, **504**, (2021), Issue 2, p.2577 a promising but puzzling candidate for one of the lightest black holes ever detected, the system that **shouldn't exist.** It falls right in the middle of the mass gap, weighing at about three solar masses with the mass $M_{(BH?)} = (3.04 \pm 0.06) M_\odot$.

It is impossible to explain existence of such a light BH by stellar evolution, light stars turn into neutron stars but not into BHs.

Gravitational waves from BH binaries

• GW discovery by LIGO strongly indicate that the sources of GW are PBHs, see e.g. S.Blinnkov, A.D., N.Porayko, K.Postnov, JCAP 1611 (2016), 036 "Solving puzzles of GW150914 by primordial black holes," and many other papers.

1. Origin of heavy BHs ($\sim 30 \boldsymbol{M_\odot}$)? There appeared much more striking problem of BH with $\boldsymbol{M} \sim 100 \boldsymbol{M_\odot}$.
2. Formation of BH binaries from the original stellar binaries.
3. Low spins of the coalescing BHs .

To form the BH with $M \sim 100 M_\odot$, the progenitors should have $\boldsymbol{M} > 100 \boldsymbol{M_\odot}$. and a low metal abundance to avoid too much mass loss during the evolution. Such heavy stars might be present in young star-forming galaxies but they are not observed in the necessary amount. So the astrophysical creation of BHs with $100 M_\odot$ was considered **impossible** in conventional astrophysics. PBHs with the observed by LIGO masses may be easily created with sufficient density.

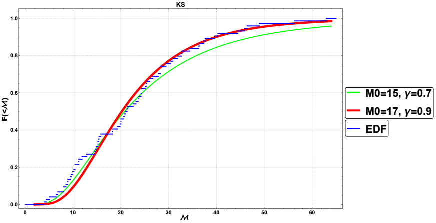
Chirp mass distribution

A.D. Dolgov, A.G. Kuranov, N.A. Mitichkin, S. Porey, K.A. Postnov, O.S. Sazhina, I.V. Simkine On mass distribution of coalescing black holes, JCAP 12 (2020) 017, e-Print: 2005.00892. The available data on the chirp mass distribution of the black holes in the coalescing binaries in O1-O3 LIGO/Virgo runs are analyzed and compared with theoretical expectations based on the hypothesis that these black holes are primordial with log-normal mass spectrum. The inferred best-fit mass spectrum parameters, $M_0 = 17 M_\odot$ and $\gamma = 0.9$, very well agree with theoretical predictions.

On the opposite, binary black hole formation based **on massive binary star evolution** requires additional adjustments to reproduce the observational data.

Chirp mass distribution

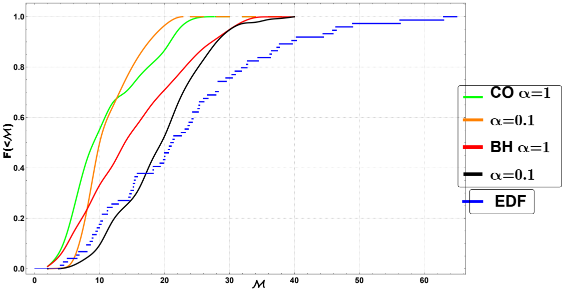
Model distribution $F_{PBH}(< M)$ with parameters $M_0 \approx 17 M_\odot$ and $\gamma \sim 1$ for two best Kolmogorov-Smirnov tests. EDF= empirical distribution function.



Similar value of the parameters are obtained in M. Raidal et al, JCAP.,2019. Feb. V. 2019, no. 2. P. 018. arXiv:1812.01930 and L. Liu, et al arXiv:2210.16094.
See also K. Postnov and N. Mitichkin, e-Print: 2302.06981.

Chirp mass distribution

Cumulative distributions $F(< M)$ for several **astrophysical** models of binary BH coalescences.



Conclusion: PBHs with log-normal mass spectrum perfectly fit the data. Astrophysical BHs seem to be disfavoured.

IMBH in globular clusters today

IMBHs with masses $(10^3 - 10^5)M_\odot$ explain formation of globular clusters (GCs) and dwarf galaxies, otherwise their formation was not understood, even mysterious. **Impossible.** The necessity of such IMBH was **stressed** by A. Dolgov, K. Postnov, in "Globular Cluster **Seeding** by Primordial Black Hole Population", JCAP 04 (**2017**) 036, e-Print: 1702.07621 [astro-ph.CO], and confirmed by subsequent observations both in GS and dwarf galaxies.
The observation of IMBH "Fast-moving stars around an intermediate-mass black hole in ω Centauri", M. Hä̈berle, N. Neumayer, A. Seth *et al*, Nature, **631**, 285–288 (2024): $M_{IMBH} \gtrsim 8200 M_\odot$;

F. Peiβker, M. Zajaček, M. Labaj, *et al*, "The Evaporating Massive Embedded Stellar Cluster IRS 13 Close to Sgr A*. II. Kinematic Structure".
Discovery of IMBH with $M \approx 3 \times 10^4 M_\odot$, 2024, ApJ **970** 74.

The origin of IMBH is impossible, if they are not primordial.

IMBHs in dwarf galaxies today

The dwarf seeding by IMBHs is confirmed by recent data, e.g. in the dwarf galaxy SDSS J1521+1404 the BH is discovered with the mass $M \sim 10^5 M_\odot$.

M. Mićić, O.J. Holmes, B.N. Wells, J.A. Irwin, "Two Candidates for Dual AGN in Dwarf-Dwarf Galaxy Mergers", Ap.J. 944 (2023) 2, 160 • e-Print: 2211.04609 [astro-ph.GA]. For the first time, astronomers have spotted evidence of a pair of dwarf galaxies featuring GIANT black holes on a collision course with each other. In fact, they haven't just found just one pair – they've found two.

J. Yang, Z. Paragi, S. Frey, L.I. Gurvits, *et al* "Intermediate-mass black holes: finding of episodic, large-scale, and powerful jet activity in a dwarf galaxy", MNRAS, 520 (2023) 4, 5964, • e-Print: 2302.06214 [astro-ph.GA] Discovery of an intermediate-mass black hole (IMBH) with a mass of $M_{BH} = 3.6^{+5.9}_{-2.3} \times 10^5 M_\odot$, **that is surely impossible to be created by accretion but PBHs might seed the dwarf formation.**
A striking example: discovery by the Hobby-Eberly Telescope at Texas's McDonald Observatory of a SMBH with $M_{BH} \approx 1.7 \cdot 10^{10} M_\odot$ i.e. 14% of the stellar mass of the galaxy.
Usually the mass of the central BH is about 0.1 % of the galaxy mass.

Antimatter history

Paul A.M. Dirac: "Theory of electrons and positrons", Nobel Lecture, December 12, 1933: "It is quite possible that... these stars being built up mainly of positrons and negative protons. In fact, there may be half the stars of each kind. The two kinds of stars would both show exactly the same spectra, and there would be no way of distinguishing them by present astronomical methods."

It seems that now we know ways to distinguish stars from an antistars by observations from the Earth. A.D. Dolgov, V.A. Novikov, M.I. Vysotsky, "How to see an antistar", JETP Lett. 98 (2013) 519, e-Print: 1309.2746.

The spectra are not exactly the same, even if CPT is unbroken and the polarization of radiation could be a good indicator or the fluxes of emitted **neutrinos/antineutrinos** from supernovae.

Dirac was the second person to talk about antimatter. In 1898, 30 years before Dirac and one year after discovery of electron (J.J. Thomson, 1897) Arthur Schuster (another British physicist) conjectured that there might be other sign electricity, ANTIMATTER.

Impossible but observed antimatter in the Galaxy

Based on the conventional approach no antimatter object is possible to be in the Galaxy. However, it was predicted in 1993 (DS) and elaborated in 2009 (DKK) that noticeable amount of antimatter, even antistars might be in the Galaxy - a byproduct of the PBH formation mechanism.

Bounds on the density of galactic antistars are rather loose, because the annihilation proceeds only on the surface of antistars as analyzed in:

C.Bambi, A.D. Dolgov, **"Antimatter in the Milky Way",** Nucl.Phys.B 784 (2007) 132-150 • astro-ph/0702350,

A.D. Dolgov, S.I. Blinnikov, **"Stars and Black Holes from the very Early Universe",** Phys.Rev.D 89 (2014) 2, 021301 • 1309.3395,

S.I.Blinnikov, A.D., K.A.Postnov, **"Antimatter and antistars in the universe and in the Galaxy",** Phys.Rev.D 92 (2015) 023516 • 1409.5736.

Anti-evidence

• **Cosmic positrons.** Observation of intense 0.511 line, a proof of abundant positron population in the Galaxy. In the central region of the Galaxy electron–positron annihilation proceeds **at a surprisingly high rate.**

• **Cosmic antinuclei.** In 2018 AMS-02 announced possible observation of six $\overline{\boldsymbol{He}}^3$ and two $\overline{\boldsymbol{He}}^4$. COSPAR 2022, 16-24 July: 7 $\overline{D}$ ($\lesssim$ 15 GeV) and 9 $\overline{He}$, $E \sim 50$ GeV. **It is not excluded that the flux of anti-helium is even much higher because low energy $\overline{\boldsymbol{He}}$ may escape registration in AMS.**

• **Antistars in the Galaxy.** S. Dupourqué, L. Tibaldo, P. von Ballmoos, "Constraints on the antistar fraction in the Solar System neighbourhood from the 10-year Fermi Large Area Telescope gamma-ray source catalog", Phys Rev D.103.083016 103 (2021). The catalog 14 antistar candidates not associated with any objects belonging to established gamma-ray source classes and with a spectrum compatible with baryon-antibaryon annihilation.

Gamma burster from star-antistar collision!? Very powerful gamma-ray burster (GRB) reported in M.E. Ravasio, O.S. Salafia, G. Oganesyan, *et al*, SCIENCE, 25 Jul 2024, **385**, Issue 6707, p. 452; 2303.16223 [astro-ph.HE].
This event got the nickname: the Brightest Of All Time or the **BOAT**.
A bright megaelectronvolt emission line was observed.

With primordial black holes impossibles become possible.