The Evidence of both Invalidating BH model at the GC and Magnetic Monopole Existence ?

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Recent New Discoveries of Astronomical Observation Near the GC

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A black hole model at the Galactic Center

The BH model at the GC is the current idea in recent 50 years.

The key for the BH model is:

Some radiations observed from the region nearby the GC

are really emitted by the gas of accretion disk around the BH.

A key observational evidence comes from stellar kinematics by the observation of motion of stars at distance about 0.1*pc* from the GC: there is a super-massive object with mass $4.6\times10^{6}m_{Sun}$

(It is impossible for another condense star such as a neutron star)

I. Recent New discoveries of Radio Astronomical Observations Near the GC :

an abnormally strong radial magnetic field

- <Nature>, 2013, 501, 391

This article reported the multi-band radio observation of a newly discovered pulsar PSR J1745-2900 which was very close to the Galactic Center. It is a magnetar with a rotation period of 3.76s. It has bright X-ray flares when discovered. This revealed the abnormally big Faraday rotation (the rotation of the polarization plane of a radio radiation in an applied magnetic field) of the pulsar. It shows that there is an dynamically important magnetic field near the central black hole. After an detailed analysis, the major observational and analytical results of the paper is: **At r=0.12 pc, the lower limit of outward radial magnetic field at the Galactic center is**:

$$\boldsymbol{B \geq 8\left[\frac{RM}{66.960m^{-2}}\right]\left[\frac{n_e}{26cm^{-3}}\right]^{-1} mG}$$

(The interstellar magnetic field in the Galaxy is usually along the Galactic spiral arms, the average strength of the magnetic field is about $1\mu\ Gauss$).

Alfven critical magnetic field for Magnetic freezing :

A plasma of the accretion disk will be prevented from approaching to the GC by the strong radial magnetic field in the neighbor of the GC when the energy density of the magnetic field is stronger than the kinematic energy density of the material, or the magnetic field is stronger than the Alfven critical value (due to the Magnetic freezing effect) :

$$B > B_{Alfven}$$

$$B_{Alfven} = (4\pi\rho v_{rot}^2)^{1/2} = \left(\frac{4\pi n c^2}{N_A}\right)^{1/2}\left(\frac{R_S}{r}\right)^{1/2} \approx 1.3\left(\frac{n}{10^4 cm^{-3}}\right)^{1/2}\left(\frac{R_S}{r}\right)^{1/2} Gauss$$

R_S : the Schwarzschild radius, $R_S = 2GM/c^2$ $M = 4.6\times 10^6 m_{Sun}$

the mass of the central massive object : $\left(\frac{R_S}{r}\right)^{1/2} = 2\times 10^{-3}$

at $r \sim 0.12pc$

$$B_{Alfven} \approx 1.3\left(\frac{n_e}{26cm^{-3}}\right)^{1/2} mG$$

A direct effect of the strong radia l magnetic field

$$B \geq 8 \left[\frac{RM}{66.960 m^{-2}}\right]\left[\frac{n_e}{26 cm^{-3}}\right]^{-1} mG$$

$$B_{Observ} > B_{Alphen}$$

The plasma of the accretion disk around the GC is prevented far from approaching to the GC by the abnormal strong radial magnetic field. $(r > 0.15\,pc)$

$$\Rightarrow$$

The radiations observed near the GC cannot be emitted by the gas of the accretion disk.,

Detected radiation emitted from the GC

a) Some radiation from the radio to the sub-mm wavelength band have been observed in the region $(10-50)R_g$ of the central black hole with mass $4.3\times10^6 m_\odot$ for the GC.

b) Sgr A* is identified as a surprisingly weak X-ray by Chandra and it is inferred as radiated from region $\le 10R_g$ due to the hour long timescale for some detected weak X-ray flare and small NIR flare.

c) The radio flux density shows a flat-to-inverted spectrum, i.e., it rises slowly with frequency with the power peaking around $10^{12}\,Hz$ in the sub mm band. $L_\nu = 4\pi D^2_{Sgr\,A*}\cdot S_\nu$, At GHz frequencies, $S_\nu \propto \nu^\alpha$, $\alpha \sim 0.3 \pm 0.1$, The spectrum continues towards low frequencies ($\sim 300\,MHz$) with no sigh of absorption. At higher frequencies the spectrum extends into Sub-mm wavelength regime, where the spectrum peaks and then suddenly cuts-off.

(Ref. Falcke and Marko (2013), review paper, arXiv : 1311.1841 [astro-ph HE] 7Nov. 2013)

A dilemma of the accretion disk model

The very strong radial magnetic field in the Galactic Center will prevent material in the accretion disk from approaching to the Galactic Center .

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The accretion disk will be prevented by from approaching to the GC, and the material of the accretion disk my not near the central black holes in AGNs.

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These radiations observed from the region nearby the GC can not be emitted by the gas of accretion disk, although the radiation from the vicinity of the black hole originates from the inflowing material of the accretion disk by the popular BH model (Yuan and Narayan, 2014) .

This is a dilemma of the standard accretion disk model of black hole at the GC.

II.
How to produce the stro ng radial magnetic field

The magnetic field by α-turbulence dynamo (Parker, 1953)

The key idea of the α-turbulence dynamo mechanism:

the induced electro-dynamic potential of turbulence is parallel to magnetic field.

$$\vec{\mathcal{E}} = \alpha\vec{B}$$

$$\alpha \equiv \alpha(\sigma t_c, \overline{\vec{v}\cdot\vec{\omega}}) = -\frac{\sigma t_c}{3c}\overline{\vec{v}\cdot\nabla\times\vec{v}} = -\frac{\sigma t_c}{3c}\overline{\vec{v}\cdot\vec{\omega}}$$

“A toroidal magnetic field ⇒ A toroidal electro-dynamic potential ⇒
A toroidal current ⇒ A poloidal magnetic field
⇒ A poloidal electro dynamic potential
⇒ A poloidal current ⇒ A toroidal magnetic field.”

$\vec{\omega} = \nabla\times\vec{v}$: the curl of the turbulent velocity of the fluid, and it is approximately equivalent to the large-scale vortex rotational angular velocity. σ is the electrical conductivity of the fluid and is the typical timescale of the turbulence.

Magnetic field by The ɑ- turbulent dynamo

By the ɑ- turbulent dynamo:

Energy density of magnetic field by ɑ- turbulent dynamo

= **Energy density of induced electric current**

= density of electrical charge × Induced electro-dynamic potential of turbulence

$$\frac{B^2}{8\pi} = ne\mathcal{E} = yne\alpha(\sigma t_c, \overline{\vec{v}\cdot\vec{\omega}})B$$

$$\mathbf{B} = 8\pi\mathbf{e}\mathbf{y}\alpha(\sigma t_c, \vec{v}\cdot\overline{\vec{\omega}})\cdot\mathbf{n}$$

n : the number density of the plasma particles ,

$\mathbf{y}$: is the ionization degree

Some relevant data in the Sun

- 1. The mass density in the solar convection zone where dynamo mechanism is valid is $\boldsymbol{\rho \approx 8\ g/cm^3}$,
or the number density of particles is: $\boldsymbol{n = 5 \times 10^{24}\ cm^3}$
2. The rotation period of the matter around the Sun in the solar convection zone is $\boldsymbol{P = 2.3 \times 10^6\ sec}$ **at** $\boldsymbol{{}^{r}/_{R} \approx 0.7.}$
3. On the differential rotation in interior of the Sun:

The gradient of angular velocity is $\frac{\Delta\Omega}{\Delta r} \approx 3.77 \times 10^{-6}\ /(sec \cdot R_{\odot})$

4. The linear rotating velocity around the rotation axis of the Sun in the solar convection zone is $V_{rot} \approx 1.3\ km/s$.
5. The corresponding velocity gradient is

$$\frac{\Delta V_{rot}}{\Delta r} \approx 0.7R_{\odot} \times \frac{\Delta\Omega}{\Delta r} \approx 2.6 \times 10^{-6}\ s^{-1}$$

6. The maximum magnetic field Sun in the solar convection zone is

$B_{max} \sim 10^5\ Gauss$

Magnetic field of the interstellar cloud

$$B \sim 10^{-19} \cdot \frac{n}{5cm^{-3}} \cdot r\{\vec{v}_{turb}, \sigma t_c\}\, Gauss \qquad (A)$$

$$r\{\vec{v}_{turb}, \sigma t_c\} = \frac{y}{y_\odot} \frac{\alpha(\sigma t_c, \overline{\vec{v} \cdot \vec{\omega}})}{\alpha(\sigma t_c, \overline{\vec{v} \cdot \vec{\omega}})_\odot}$$

The value of factor $\alpha(\sigma t_c, \overline{\vec{v} \cdot \vec{\omega}})$ is unclear.

In the interstellar cloud , W51 e2, the strongest magnetic field may reach at 20mG about with the number density $n = 2.7 \times 10^7\ cm^{-3}$ near the collapsing core W51 e2 (Koch et al.2012).

B = 20mG may be produced only for the very dense interstellar cloud with a condition

$$\frac{n}{2.7 \times 10^7 cm^{-3}} \frac{r\{\vec{v}_{turb}, \sigma t_c\}}{4 \times 10^{10}} \sim 1$$

Taking the ratio $r\{\vec{v}_{turb}, \sigma t_c\} \sim 4 \times 10^{10}$ and $n \sim 26\ cm^{-3}$ (Eatough et al., 2013) at the distance of 0.12pc from the Galactic Center, the magnetic field with a lower limit of 8mG is hard be hardly produced by α-turbulence dynamo mechanism (eq.(A)) $B \leq 1\ \mu G$

Two dilemma and a solution

1. The first **dilemma of the standard accretion disk model of black hole at the GC:** The accretion plasma is clearly prevented from approaching to the GC by the radial magnetic field in the region near around the GC at least as explicitly demonstrated above. Thus, the accretion material can't reach the region near the central "black hole". Consequently, the radiations observed near the GC cannot be emitted by the gas of the accretion disk.
2. The second dilemma: The observed magnetic field with a lower limit of 8mG at the distance of 0.12pc from the GC can not being produced by the α-turbulence dynamo mechanism (which is the most effective mechanism known up to now)

A Solution: We note that the important discovery of very strong radial magnetic field in the Vicinity of the GC is consistent with the prediction from our model of supermassive object (SMO) with magnetic monopoles (Peng and Chou 2001).

III.
On the super-massive AGN (non black hole) model with mag netic monopoles

Magnetic monopole

- In 1931 Dirac first predicted there could be magnetic monopoles in the nature. In 1974 particle physicists ‘t Hooft and Polykov proposed a possible super-massive magnetic monopole in the frame of GUT, $\boldsymbol{m_m \sim 10^{16} m_p}$.

magnetic charge of a magnetic monopole is about 3 times of one proposed by Dirac: $\boldsymbol{g_m = 3\frac{hc}{2e} = 9.88 \times 10^{-8}}$ $(\boldsymbol{c.g.s.})$.

A small amount of magnetic monopoles would be produced by the rapid oscillation and thermal fluctuation of Higgs field during the phase transition stage of the very early universe According to the view of the improved inflation cosmology.

Parker (1970) gave an upper limit of the number of magnetic monopoles by taking the dissipation of the magnetic field in the Galaxy:

$$\boldsymbol{\zeta \equiv \frac{N_m}{N_B} \sim 10^{-20\pm 1}}$$

The Rubakove –Callen effect

- **The Newtonian saturated content** (with which the magnetic Coulomb repulsion of monopoles is balanced with Newtonian gravity) of the magnetic monopoles in an object is

$$\zeta_n = \frac{G m_m m_B}{{g_m}^2} \approx 2 \times 10^{-25}$$

RC effect (1981): in the GUT, magnetic monopole can catalyze the nuclear decay:

$$pM \to e^+ \pi^0 M \quad (85\%)$$

Or $pM \to \mu^+ \mu^- \pi^0 M \quad (15\%)$

(while the cross section of the reaction may reach at the order of magnitude of that in strong interaction)

$$< \sigma v > \sim (10^{-27} - 10^{-36})\ cm^2$$

The main idea of our model

1) Taking the Rubakov-Callan (RC) effect in particle physics: (Magnetic monopoles may catalyze nucleons to decay to leptons (number of baryons is non-conserved) which provides the main energy for quasars and AGNs. This may replace black hole model (the accretion model acts only as a minor energy provider).
2) The gravitational effect around the super-massive object in the galactic center is similar to black hole. However, the super-massive object containing sufficient magnetic monopoles has neither the horizon nor the central singularity of the black holes . This is because the reaction rate of the nucleon decay catalyzed by magnetic monopoles is proportional to square of mass density, and both the leptons and photons from decaying emit outward, the central density cannot approach infinity. Combined with RC effect from particle physics, our model can avoid the central singularity problem of black hole theory in GR, which make physical theories self-consistent and rather harmonic in the nature.

Our model predictions about the Galactic center

- 1) Plenty of positrons are produced, the production rate is about $10^{43} e^{+}/sec$. This is consistent with high-energy astrophysical observations.
 2) The higher energy radiation above 0.5MeV can be emitted, the integral energy of those high energy radiation is far higher than the total energy of the spectra of electron and positron annihilation, as well as the thermal luminosity of the central object. This prediction is well consistent with observations.
 3) The magnetic monopole condensed in the core region of the super-massive object will produce radial magnetic field. The magnetic field strength at the surface of the object is about 20-100 Gauss.

 (the radius of the object is about 8×10^{15} cm)

We declared clearly in our article: This prediction is the most critical one, which can be testified by future radio observations.

Because the magnetic field strength decrease proportionally to the square of the distance from the source, so we have

$B \approx (10 - 50)\, mG$ at $r = 0.12 pc$

Predictions(continue)

4) The supper-massive objects with saturated magnetic monopoles in the centers of all AGNs in the region $D \leq 50Mpc$ by the Earth may be the sources of the observed ultra high energy cosmic ray.

5) The surface temperature of the super-massive object in the Galactic center is about *120K* and the corresponding spectrum peak of the thermal radiation is at $10^{12}\,Hz$ in the sub-mm wavelength regime. This prediction is basically consistent with the recent observation (Falcke and Marko, 2013).

The non- thermal radiation such as synchrotron radiation, may be emitted due to the motion of the relativistic electrons in the magnetic field.

However, quantitative comparison of observations with theory is rather difficult now, because the power indexes of both the thermal radiation and the non- thermal radiation for the radio wavelength band have not been well determined yet up to now.

Conclusions

1) It could be an astronomical observational evidence of the existence of magnetic monopoles which it predicated in particle physics.
2) The black hole model and accretion disk model of quasars and AGNs are not physical.
3) Our AGN model containing magnetic monopoles could be a reasonable one.

The radiation in the emitted from the region near the GC may be naturally explained by our model.

Challenge on the BH Models for other quasars and AGCs

1. about very strong radial magnetic field in the center of AGNs

Zamaninasab M.et al., 2014, “Dynamically important magnetic fields near accreting supermassive black holes” , < Nature >, Vol. 510, 126.

The authords did a statistical analysis on 76 radio-loud active galaxies and **concluded that there were very strong radial magnetic field in the galactic center preventing material in the accretion disk from falling in.**

i.e. The accretion disk is not near the central black holes in AGNs.

This could invalidate the standard accretion disk model of black holes in AGNs.

2. On the Infrared radiation of quasars

The significant new discovery of quasar observations (Infrared luminosity observations of quasars):

In the 21 high-redshift quasars ($5.8 < z < 6.4$ **), their observation discovered:**

There were two quasars with no detection of infrared radiation from the hot dusts. The authors of the article explained as: Those two quasars without hot-dust emission probably are the first generation of quasar formed in the dustless environment. They were so young and the number of hot dust accreted around them were so less that the radiation cannot be observed.

Jiang L., et al., 2010, “Dust-free quasars in the early Universe” <Nature>, Vol. 464, Issue 7287, pp. 380-383 (2010).

In my idea

- **The observation of the two high-redshift quasars without hot dusts mentioned above;**

  The strong radial magnetic field observed in the Galactic center;

  The strong magnetic fields might existed in the center of the 76 radio-loud AGNs.

  There are only magnetic-braking accretion disk around the central object which preventing matter from approaching the surface the object (black hole). This shows that the accretion flow cannot provide enough luminosity.

- **This is in favour of our non-black hole model of the galactic nuclei with magnetic monopoles again.**

  This is a challenge for the current popular black hole model.

3. On Jets of AGNs

Sell et al., 2014, Apr. arX iv:1404.0677[astro=ph.GA] 2 Apr. 2014

ABSTRACT
We investigate the process of rapid star formation quenching in a sample of 12 massive galaxies at intermediate redshift ($z \sim 0.6$) that host high-velocity ionized gas outflows ($v > 1000$ km s^{-1}). We conclude that these fast outflows are most likely driven by feedback from star formation rather than active galactic nuclei (AGN). We use multiwavelength survey and targeted observations of the galaxies to assess their star formation, AGN activity, and morphology. Common attributes include diffuse tidal features indicative of recent mergers accompanied by bright, unresolved cores with effective radii less than a few hundred parsecs. The galaxies are extraordinarily compact for their stellar mass, even when compared with galaxies at $z \sim 2 – 3$. For 9/12 galaxies, we rule out an AGN contribution to the nuclear light and hypothesize that the unresolved core comes from a compact central starburst triggered by the dissipative collapse of very gas-rich progenitor merging disks. We find evidence of AGN activity in half the sample but we argue that it accounts for only a small fraction (. 10%) of the total bolometric luminosity. We find no correlation between AGN activity and outflow velocity and we conclude that the fast outflows in our galaxies are not powered by on-going AGN activity, but rather by recent, extremely compact starbursts.

4.On the BH mass of the center for AGNs

It is now generally believed by most astronomers that bright quasars observed at large redshift (for example, z >1 or even z > 5) are supermassive black holes formed in th e primordial universe. The spectacularly huge luminosity is supplied by the accretio n of matter outside these black holes. As a result, the mass of nearby galactic nuclei and quasars must be greater than that of the remote quasars with larger redshift. This is because the mass of the black holes must continuously increase due to accretion. But the deduction is just contrary to the observation that no supermassive black hole with mass $m = (10^9 - 10^{10}) m_{Sun}$

This is the dilemma of the black hole model of quasars and active galactic nuclei (A GNs).

However, it is naturally explained by our AGN model containing magnet ic monopoles. The mass of the supermassive object must decrease gra dually due to the baryons decaying catalyzed by the magnetic monopo les and the decaying products (including the pions , muons , positrons and the radiation) would going out of the object continuously.

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Thanks