The Explosion at the Center of our Galaxy

Kenneth Dalton

email: kxdalton@yahoo.com

Abstract

At the center of the Milky Way, our black hole may have suddenly changed from supermassive to intermediate-mass status. In doing so, it would have emitted an enormous burst of electromagnetic radiation. Here, the total energy of that burst is calculated and compared with the Fermi bubble data.

In the electron-positron model [1], black holes naturally separate into two distinct varieties. Those of intermediate mass are supported against gravity by electron degeneracy pressure, while supermassive black holes are supported by ideal gas and radiation pressure. Their equilibrium states are reproduced here:

Table 1: Intermediate-mass				
M ($M_\odot$)	$R > R_s$ (cm)	ρ_0 (g cm^{-3})	P_0 (Pa)	ϵ_{F0} (eV)
10^3	$4.8(10^{13})$	$2.6(10^{-5})$	$3.9(10^{9})$	2.1
10^4	$2.25(10^{13})$	$2.6(10^{-3})$	$8.4(10^{12})$	$4.5(10)$
10^5	$1.05(10^{13})$	$2.6(10^{-1})$	$1.8(10^{16})$	$9.6(10^{2})$
10^6	$4.8(10^{12})$	$2.6(10)$	$3.9(10^{19})$	$2.1(10^{4})$
$4(10^6)$	$3.0(10^{12})$	$4.2(10^{2})$	$4.0(10^{20})$	$1.4(10^{5})$
$8(10^6)$	$2.4(10^{12})$	$1.7(10^{3})$	$3.9(10^{22})$	$3.3(10^{5})$

Table 2: Supermassive				
M ($M_\odot$)	$R = R_s$ (cm)	ρ_0 (g cm^{-3})	P_0 (Pa)	kT_0 (eV)
$8(10^6)$	$2.4(10^{12})$	$2(10^{3})$	$3.9(10^{22})$	$1.1(10^{5})$
10^7	$3(10^{12})$	$1.3(10^{3})$	$2.5(10^{22})$	$1.1(10^{5})$
10^8	$3(10^{13})$	$1.3(10)$	$2.5(10^{20})$	$6.2(10^{4})$
10^9	$3(10^{14})$	$1.3(10^{-1})$	$2.5(10^{18})$	$2.3(10^{4})$
10^{10}	$3(10^{15})$	$1.3(10^{-3})$	$2.5(10^{16})$	$8(10^{3})$
10^{11}	$3(10^{16})$	$1.3(10^{-5})$	$2.5(10^{14})$	$2(10^{3})$

A critical mass of 8×10^6 $M_\odot$ defines the transition region.

Over the course of time, these black holes gradually lose energy by heating ionized gas in the accretion disk. They also suffer the loss of electrons, positrons and low-level radiation directly from the black hole itself. This raises the possibility that our black hole (at 4×10^6 $M_\odot$) may have undergone a spontaneous transition from supermassive to intermediate-mass status. The radius of the metastable state was $R = R_s = 1.2 \times 10^{12}$ cm. At a point in time millions of years ago, the radius suddenly increased to $R = 2.5R_s =$

$3\,\mathrm{x}\,10^{12}$ cm, releasing the electromagnetic radiation. The remaining leptons settled into the stable quantum state that exists today.

The pressure in a supermassive black hole is given by

$$P = P_{\text{gas}} + P_{\text{rad}} = \frac{\rho}{m} kT + \frac{a}{3} T^4 \tag{1}$$

where $a = \pi^2 k^4/15(\hbar c)^3$. In states near the transition region, the gas pressure is far greater than the radiation pressure. This is due to the very high density of leptons. For purposes of calculation, it is simpler to adopt the uniform density model [2], in which case the pressure satisfies

$$P = P_0 \left(1 - \frac{r^2}{R^2}\right) \tag{2}$$

Ignoring the radiation pressure leaves the linear ideal gas relation between pressure and temperature, so that

$$T = T_0 \left(1 - \frac{r^2}{R^2}\right) \tag{3}$$

The energy density of radiation is

$$u_{\text{rad}} = a\,T^4 = a\,T_0^4 \left(1 - \frac{r^2}{R^2}\right)^4 \tag{4}$$

which yields the total radiant energy

$$U_{\text{rad}} = \int_0^R u_{\text{rad}}\, 4\pi r^2\, dr = 1.6\,\mathrm{x}\,10^{58}\,\mathrm{erg} \tag{5}$$

where $M = 4\,\mathrm{x}\,10^6\,\mathrm{M}_\odot, R = 1.2\,\mathrm{x}\,10^{12}$ cm and $T_0 = 1.3\,\mathrm{x}\,10^9$ K.

The energy calculated here is an order of magnitude greater than the current upper estimates for the Fermi bubbles. Nevertheless, given the experimental uncertainties and given the limitations of the model, it may be said that the work is in substantial agreement with observation.

References

[1] K. Dalton, “Supermassive Black Holes”, *JHEPGC*, **5**, 984-988 (2019). https://doi.org/10.4236/jhepgc.2019.53052

[2] K. Dalton, “The Galactic Black Hole”, *Hadronic J.* **37(2)**, 241 (2014) Also, http://vixra.org/abs/1404.0067