Evidence for Primordial Black Holes

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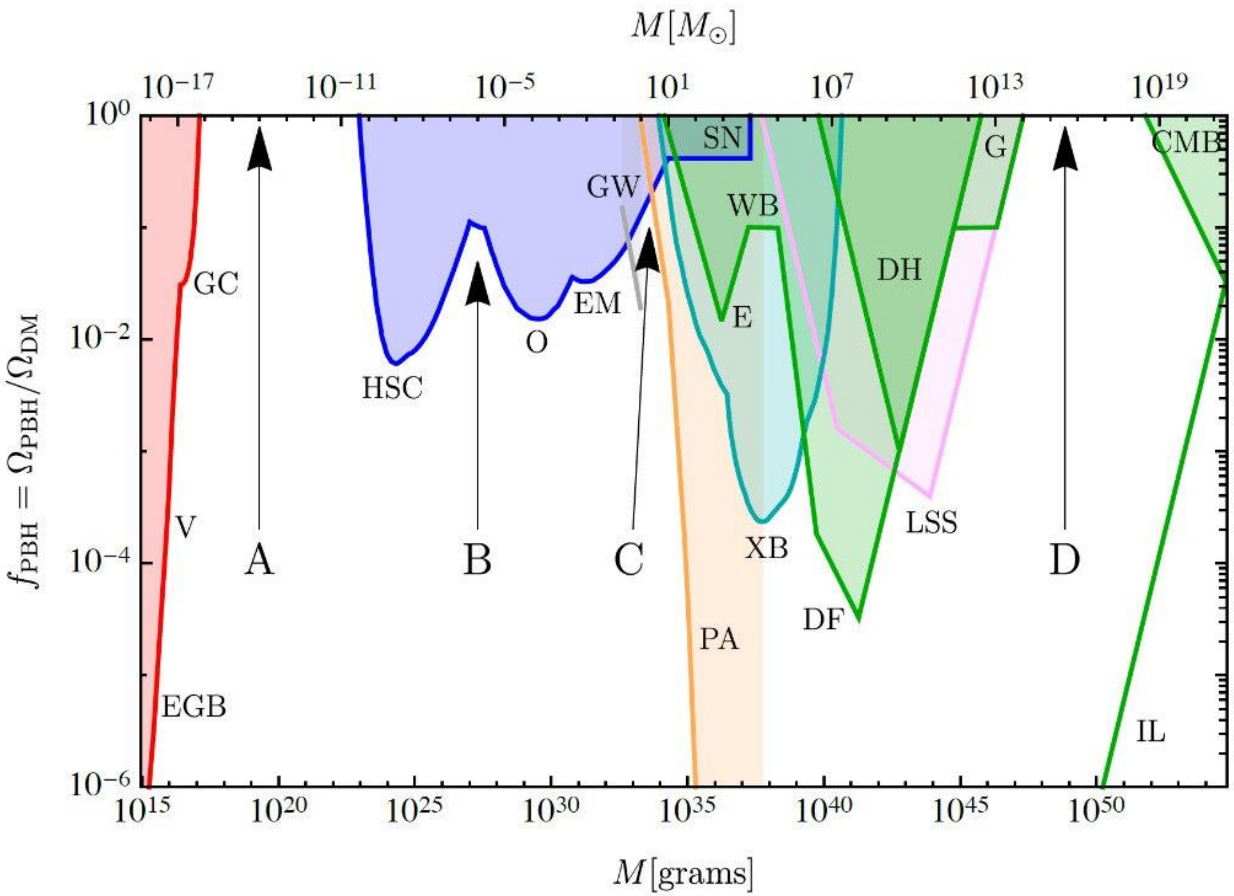
Constrains on PHB dark matter



Constraints from:

1. Evaporation (red);
2. Gravitational waves (gray);
3. Dynamical effects (green);
4. Accretion (light blue);
5. Cosmic microwave background anisotropies (orange);
6. Lensing (blue);
7. Large-scale structures (purple).

- Chandrasekhar limit: A stellar black hole is a black hole formed by the gravitational collapse of a massive star (3 or more solar masses) at the end of its lifetime. The process is observed as a supernova explosion or as a gamma ray burst. Such a black hole will have a mass of at least 1.44 solar masses.

Lensing Evidence

- If dark matter mostly consists of compact bodies if would create a caustic network, leading to unstable changes in quasar light as it passes through a complex amplification scheme.

⇨ In 1993, Hawkins presented the first evidence of a cosmological distribution of PBHs based on microlensing of quasar light curves.

- In his 1985 paper Paszynski suggested searching for compact objects in the halo of the Milky Way by microlensing stars in the Magellanic Clouds.

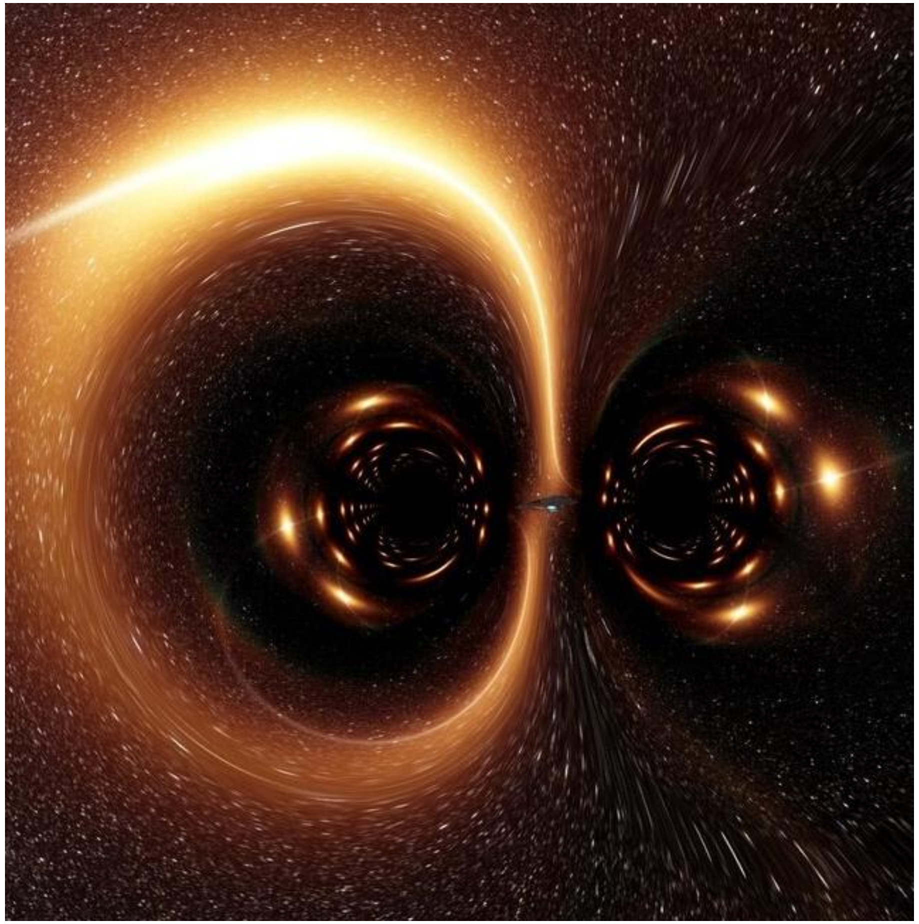
- Time of the half-intersection brightness curve depends on three quantities: M_D, 1/d and v.

$$1/d = 1/d_{OD} + 1/d_{DS}$$

$$\Delta t_{1/2} = \frac{\sqrt{4GM_D d}}{v}$$

⇨ Microlensing results of Paszynski and MACHO Collaboration indicate that compact objects of near-Solar masses cannot dominate in the dark matter.

LIGO/Virgo Evidence



- Following the detection of gravitational waves (GWs), Bird and Garcia-Bellido claimed that the expected merger rates of binary PBH systems, formed in late times in compact halos, are compatible with LIGO/Virgo analysis results if they include all of dark matter.

However, the results are twofold:

⇨ If there are few PBH, then merges occur at the rate observed by LIGO/Virgo.

⇨ If there are many PBH, then binary systems destroy each other and thereby the rate of merger is suppressed, thus merger rate could still be compatible with the one observed by LIGO/Virgo.

- Merger events and evolution of black holes binaries were studied in details via N-body simulations. Many researches obtained similar results independently.

Clusters of PBHs

- The main difference between dark matter particles and black holes is an enormous mass of the latter.

⇨ This leads to significant Poisson fluctuations in the spatial distribution of PBHs and ultimately results in the formation of gravitationally-bound PBH clusters.

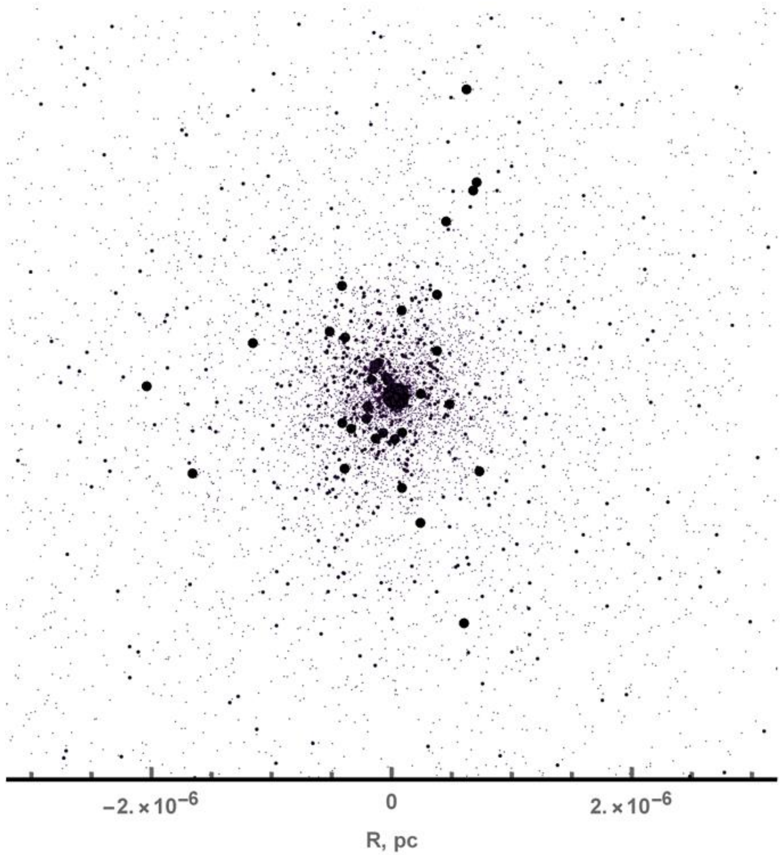
- Some of the constrains should be reconsidered in case of clusters of PBHs, e.g.:

    1. Dynamical constraints;
    2. Gravitational-waves constraints.

- Clustering of PBHs should also affect:

    1. Formation of non-linear structures;
    2. Sizes and mass to light ratio of ultra-faint dwarf galaxies.

- Clustering of black holes might be an evidence in favor for PBHs existence.



The typical spatial black holes distribution within cluster

Thank you for your attention!