

UNIVERSITY Of Warsaw

Astronomical Observatory



Atmospheric Turbulence challenges for hunting Black Holes with ground based telescopes

Algita Stankevičiūtė



10th OPTICON Gaia Science alerts workshop, 18-20 December

algita@astrouw.edu.pl

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Content



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Black Holes

Types of Black Holes:

- a) Stellar Mass Black Holes: $10 100 \text{ M}_{\odot}$
- b) Supermassive Black Holes: $10^6 10^{10} M_{\odot}$
- c) Intermediate Mass Black Holes: $100 10^5 M_{\odot}$



Illustration: Roen Kelly (Astronomy 2018)





a) From compact stellar clusters

Formation of IMBHs



b) From direct collapse of unpolluted gas in very massive stars (Bin Yue+2014)

c) From Dark Matter (Mar Mezcua+2017)







Gravitational Microlensing

Planetary society+2019

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Concept



Fig. 1. Gravitational Microlensing phenomenon in case of ground based observatory



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Microlensing of IMBHs



Fig. 2. Gravitational microlensing phenomenon by the IMBHs with a mass of 2000 ${\rm M}_\odot$

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VARSAW



Very Large Telescope





Fig. 3. ESO VLT

http://certificate.ulo.ucl.ac.uk/modules/year_one/www.eso.org/projects/vlti/AT/index_at.html

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Fig. 4. GRAVITY

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VLTI "GRAVITY"







http://www.eso.org/sci/facilities/p aranal/instrume-nts/gravity/inst.html

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VLTI "GRAVITY"

- Two independent interferometers (fringe-tracker and science channel);
- Interferometry with four telescopes;
- Control-loops to track fringes;
- Single-field and dual-field mode;
- Polarization split/combined modes;
- Three spectral resolutions (20, 500, 4000);
- Instrument contained in cryostat to mitigate thermal background and provide ultra-high stability;
- Allows measurement of inclination;
- Direct measurement of planet mass;
- Allows to infer alignment of planets with rotation axis, companions, disks, other planets;
- Probes parameter space between transits/ rad vel & direct imaging.





galaxy NGC 7469



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Overview





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Adaptive Optics



Shack-Hartman wavefront sensor



http://www.ctio.noao.edu/~atokovin/tutorial/part3/wfs.html

Brian Koberlein+2013



Plane wave



Results

Distorted wave





Changing coherence length





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Results

Fresnel diffraction







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Results

Square mask – multiple patterns





Conclusions

- Black Holes are most wondrous objects in all Universe, they attracted wide attention due to importance in understanding how the black holes at various masses are formed;
- Gravitational microlensing phenomenon is a very powerful tool to detect and analyse IMBHs.
- VLTI Gravity is one of the best candidates for achieving ultra-precise astrometric data;
- Adaptive optics system can help to achieve a better precision data while minimizing atmospheric turbulence.



Thank You for Your Attention!

