Astrometry and Narrow-band Imaging of the Galactic Center with ULTIMATE-Subaru

Shogo Nishiyama
(Miyagi Univ. of Education)
What I want to understand
1. Interaction between SMBH and stars
2. How Nuclear star cluster (NSC) evolved

Why we need Ultimate?
Strong Extinction and Confusion

What I want to do
Search for hypervelocity stars (HVSs)
Search for stellar cluster remnants

How to find them
(1) Astrometry
(2) Narrow-band Photometry
Summary

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Observations of the GC

Why NIR? Interstellar Extinction

\[ \lambda \text{ dependence of extinction} \]

- **Optical (0.5 \( \mu m \))**
  - \( \sim 30 \text{ mag} \)
  - \( 10^{-12} \)

- **NIR (1 \( \mu m \))**
  - \( \sim 10 \text{ mag} \)
  - \( 10^{-4} \)

- **NIR (2.2 \( \mu m \))**
  - \( \sim 2.5 \text{ mag} \)
  - \( 1/10 \)

*Schodel+ 10*

*Fritz+ 11*

*Nishiyama+ 06, 08, 09*
Observations of the GC

Why GLAO? Confusion

1° ~ 140 pc

JHKs IRSF/SIRIUS

a few stars/arcsec²

12.5” ~ 0.5 pc

K-band IRCS/AO188

several tens of stars/arcsec²
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Hypervelocity Stars

Hypervelocity stars (HVS; Brown+05, 06, 07, 09)

http://www.youtube.com/watch?v=Gtie6QD-3CY
Hypervelocity Stars

Orbits of S-stars (<1"=0.04pc)

Keck/UCLA Galactic Center Group
Hypervelocity Stars

Hypervelocity stars (HVS; Brown +05, 06, 07, 09)

Indirect evidence of SMBH, Origin of S-stars

Proper motion $\sim 10$ mas/yr

$\leftarrow$ Astrometry with GLAO
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The Galactic NSC

Galactic NSC (3.6-8μm, SST, Schodel 11)

10' ~ 20 pc

Stellar Mass of host galaxy [Msun]

Mass of NSC [Msun]

Early-type

(Georgiev+ 16)
**The Galactic NSC**

How NSC evolved?

Star formation history in the Nuclear bulge

- **Star formation rate**
  - $\sim 0.075$ Msun/yr
  - @central 400 pc
  - (Yusef-Zadeh+ 09, Matsunaga+ 11)

  $\rightarrow$ dozens clusters (several % of $M_{NSC}$)

But

- 2 clusters known

  $\rightarrow$ so far unknown cluster remnants & tidal streams

N-body simulation

Fujii+ 08
**Observations: Narrow-band**

How to find them? (1) Narrow-band phot.

- B0 dwarf
- K4.5 giant

- CO band
- NB225
- NB234

- 20 candidates

(Nishiyama & Schödel 13, Nishiyama+ 16)
Observations: Narrow-band

How to find them? (1) Narrow-band phot.

11/20 candidates \( \rightarrow \) age < 100 Myr

Typical Error

Observations: Narrow-band phot.

(Nishiyama+ 16)

Typical Error

isochrones: Padova code
Marigo+08, Marigo & Girardi 07
**Observations: Narrow-band**

How to find them? (1) Narrow-band phot.

- Typical Error
- How to find them?
  - Narrow-band observations:

- T_{eff} [K]
- M_{bol}

- 100Myr
- 500Myr
- 1Gyr
- 50Myr

- Z = Z(sun)

- 0.5 – 0.6” FWHM

- w/o AO
- w/ AO

- GLAO target

(Nishiyama+ 16)
**Observations: Astrometry**

How to find them? (2) Astrometry

Relaxation timescale \(> \mathcal{O} \) (Gyr) (Alexander 05)

\(<\sim 1\)Gyr stars \(\leftrightarrow\) not dyn. relaxed

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HST/NICMOS/NB
(Dong+11)

FWHM:
\(\sim 200\)mas@1.9\(\mu\)m

SN=20:
\(\sim 16\) mag

\(\delta p \sim 40\) mas

100 observations
(accuracy \(\propto 1/\sqrt{N}\))

\(\rightarrow \sim 4\) mas

\(> 5\sigma\) for 4 yrs

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Stellar Proper motion

\(4\) mas/yr

\(\sim 5\) mas/yr
Observations: Astrometry

How to find them? (2) Astrometry

Relaxation timescale > $\mathcal{O}$ (Gyr) (Alexander 05)

$\ll$ 1Gyr stars $\Leftarrow$ not dyn. relaxed

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FWHM:
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$\delta p \sim 40 \text{ mas}$

100 observations
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$> 5\sigma$ for 4 yrs

100 x 100 pc (40’)

1-min $\times$ 100obs

$\times 3\times3 \text{ FoV} = 15 \text{h}$

$\rightarrow 8$ (-half) nights/yr

(50% efficiency)
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Questions

Q1. Coevolution between SMBH/NSC & the Galaxy
Q2. Wide-field camera with NB filters (~2.3μm)
Q3. NB imaging: possible but not competitive
   Astrometry: pixel scale not enough
Q4. --
Q5. Smaller pixel sampling is better for astrometry.
Q6. interested in a tunable filter
Q7.
Q8. Yes! (IRCS/IRD, but for different science cases)