Science Strategy of NAOJ

: Compact objects, extreme physics, & multimessenger

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On behalf of Science Roadmap Committee of NAOJ

Current Trend in the Field
世界的な動向

- Ultimate Purpose of Compact Objects, Extreme Physics, & Multi-messenger (当該分野の究極的な目的)
  - We will clarify where and how the various elements and high-energy cosmic-ray particles in the universe were generated.

- (More practical) Goals (当該分野の目標)
  - Origin of matter and elements
  - Evolution of matter in the Universe
  - Nature of high-energy and/or high-density objects

Current Status of the Field
現在までの到達点 (1)

- Origin of matter and elements
  - Light elements: Big-bang nucleosynthesis. Possible discrepancy about Li?
  - Heavy elements up to Fe: mostly from supernovae (core-collapse and Ia)
  - Heaveir than Fe: r-process confirmed from NS-NS merger, but still other sources?
- Evolution of matter in the Universe
  - Observational progress about chemical evolution of the universe
    - Metal poor stars in the Galaxy
    - Metallicity evolution of galaxies to high redshifts

Current Status of the Field
現在までの到達点 (2)

- Nature of high-energy and/or high-density objects
  - Variety of supernovae, observation to z>~1
  - Numerical simulations of CCSNe: close to reproduce explosions, but still many problems
  - Type Ia: explosions of white dwarfs, but progenitor system unknown
  - Interesting transients in various wavelengths
    - Gamma-ray bursts: long = massive star collapse, short = NS-NS merger, but yet small sample for short GRBs. Varieties emerging for long GRBs (e.g., ultra-long)
    - Fast radio bursts: a new enigmatic transient in cosmological distances, intensive studies underway in the world
  - Gravitational waves
    - So many BH-BH mergers now detected, giving a lot of hints for their production and evolution

Future Trends
今後の世界的動向

- Origin of matter and elements
  - 30m-class telescopes for metal-poor stars
  - Theoretical simulations from 1st principle for supernovae, NS-NS mergers, …
- Evolution of matter in the Universe
  - Galactic archeology: Subaru-PSF, Roman, JASMINE
  - Probing the early universe by distant transients: Euclid, Roman, Rubin, …
- Nature of high-energy and/or high-density objects
  - Multi-messenger astronomy lead by LVK GW observatories, IceCube, Hyper-K, …
    - Supported by EM observatories at various wavelengths
  - Time-domain: revolution will come by Rubin, follow-up by Subaru/PFS

Science Strategy of NAOJ
国立天文台の科学戦略

Scientific Goals and Methods for “Compact objects, Extreme physics, & multi-messenger” by projects related to NAOJ

- Establishing a New Vision of the Universe through the Advancement of Time-Domain & Multi-messenger Astronomy
- Formation and Evolution of Supermassive Black Holes and Extreme Phenomena
- Unraveling the Origins of Elements Through Galactic Archaeology

Science Strategy of NAOJ
国立天文台の科学戦略

Scientific Goals and Methods for “Compact objects, Extreme physics, & multi-messenger”

- Establishing a New Vision of the Universe through the Advancement of Time-Domain & Multi-messenger Astronomy
  - GW astronomy: KAGRA, KAGRA-HF, Einstein Telescope
  - Fast radio bursts: SKA
  - Follow-up observations: Subaru, TAO, Seimei, ALMA, ASTE, TMT, LST, LAPYUTA

Science Strategy of NAOJ
国立天文台の科学戦略

Scientific Goals and Methods for “Compact objects, Extreme physics, & multi-messenger”

- Formation and Evolution of Supermassive Black Holes and Extreme Phenomena
  - Studying the extreme environment around SMBHs (east-Asia and global VLBI)
  - Elucidation of Gas Supply Mechanisms to Black Holes (ASTE, ALMA, JASMINE)
- Unraveling the Origins of Elements Through Galactic Archaeology
  - opt-IR spectroscopy by Subaru/PFS, Seimei, TMT
  - Stellar distribution and motions in the Galaxy: JASMINE

Summary
まとめ

表3　「高密度天体・極限物理・マルチメッセンジャー天文学」の科学目標と手法一覧

大目標	課題	手法（波長・特色）	第5期中期計画における対応プロジェクト	開始時期
突発天体のマルチメッセンジャー観測による恒星進化の全貌解明と極限物理の探求	地上干渉計による重力波天文学の推進	重力波・地上干渉計	(成果) KAGRA (建設) Einstein Telescope (検討) KAGRA-HF	KAGRA-HF 2030年代前半 Einstein Telescope 2036
	高速電波バーストの起源解明と宇宙論研究	電波サーベイ	(成果) (建設) SKA (検討)	SKA 2031
	追観測による時間領域天文学の推進	波長を問わず、迅速な追観測が可能にさせる柔軟な運用	(成果) すばる, TAO、せいめい他国内可視赤外望遠鏡, ALMA, ASTE (建設) TMT (検討) LST, LAPYUTA	TMT 2035 LST LAPYUTA
巨大ブラックホールの起源と進化の解明	高角分解能観測によるブラックホール周辺現象の観測	電波VLBI	(成果)　東アジアおよびグローバルVLBI (建設) (検討)	
	ブラックホールへのガス供給メカニズムの解明	可視光、電波	(成果) ASTE、ALMA (建設) JASMINE (検討)	JASMINE 2031
宇宙における元素の起源と進化の解明	銀河考古学による元素組成進化の解明	可視赤外分光観測	(成果) すばる, せいめい (建設) TMT, JASMINE (検討)	TMT 2035 JASMINE 2031