BRINGING ASTRONOMY BACK HOME

DESIGNING HIGH PERFORMANCE LINEAR ALGEBRA ALGORITHMS FOR NEXT GENERATIONS OF GROUND-BASED TELESCOPES

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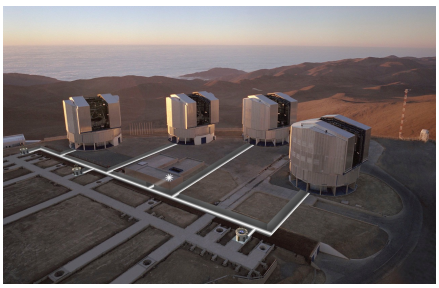
Australian National University

l'Observatoire de Paris – LESIA
Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

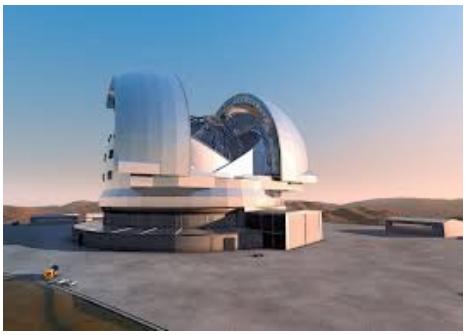
The KAUST Extreme Computing Research Center (ECRC) collaborate with astronomers from the Paris Observatory, the National Astronomical Observatory of Japan (NAOJ) and the Australian National University to develop the advanced Extreme Adaptive Optics (Extreme-AO) algorithms that will meet the formidable habitable exoplanet imaging challenge. Imaging exoplanets with large ground-based telescopes is very challenging due to the star/planet contrast and blurring induced by Earth's atmosphere. Powered by ECRC's high performance linear algebra algorithms, images taken by large telescopes can be corrected in real-time using Extreme-AO. The work of the project team adds a new chapter to the historical contributions of the Middle East to the field of observational astronomy.

THE GROUND-BASED TELESCOPES



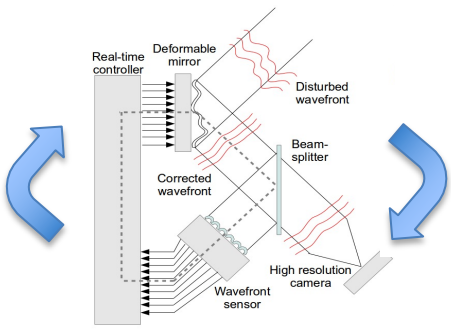
THE VERY LARGE TELESCOPE

THE SUBARU TELESCOPE



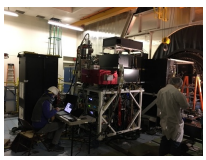
THE EUROPEAN EXTREMELY LARGE TELESCOPE

EXTREME AO – SOFT/HARD REAL-TIME

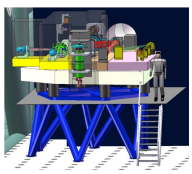


THE CURRENT AND FUTURE AO INSTRUMENTS (CREDITS: ESO/NAOJ/ANU)

SCEXAO
THE SUBARU CORONOGRAPHIC EXTREME AO

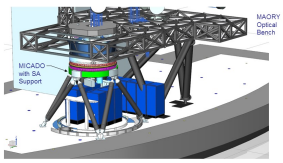


EPICS
EXOPLANET IMAGING CAMERA AND SPECTROGRAPH

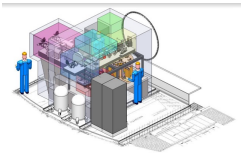


MAORY
MULTI-CONJUGATE ADAPTIVE OPTICS RELAY

MICADO
MULTI-ADAPTIVE OPTICS IMAGING CAMERA FOR DEEP OBSERVATIONS



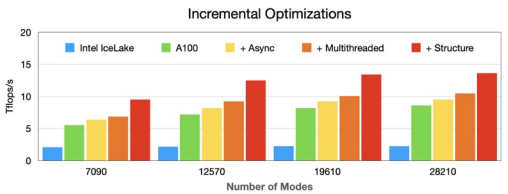
MAVIS
MCAO ASSISTED VISIBLE IMAGER AND SPECTROGRAPH

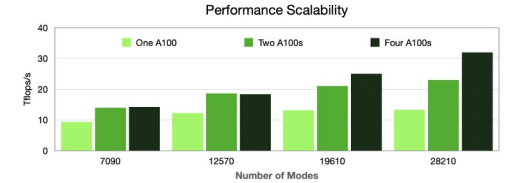


HIGH PERFORMANCE LINEAR ALGEBRA ALGORITHMS

SOFT REAL-TIME

High Performance Discrete Time Algebraic Riccati Equation





Problem Equation

$$X = A^T XA + Q - A^T XB(R + B^T XB)^{-1} B^T XA$$

Double Prec w/ Dense Linear Algebra

The **larger** number of Modes, the **better** AO performance will be.

We finish the workload within 7 minutes and meet the application requirement.

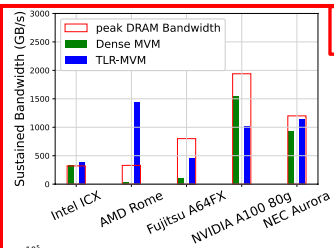
Code available at: https://github.com/ecrc/dare

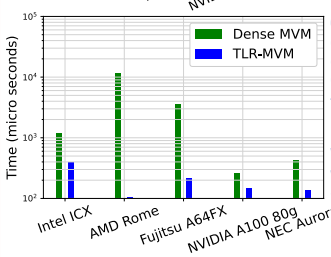
The code supports **two** software stacks: **STARPU + Chameleon** and **Parsec + DPLASMA**.

We only show performance of STARPU + Chameleon. We are still working on performance Opt of Parsec + DPLASMA.

HARD REAL-TIME

Tile Low-Rank Matrix-Vector Multiplication (TLR-MVM)





On MAVIS dataset, we deploy TLR-MVM that can exploit data sparsity and data locality to approximate the computation of original matrix vector multiplication.

We finish the workload within 150 us and meet the application requirement.

A collaboration of

NAOJ National Astronomical Observatory of Japan
Australian National University
Université de Paris
l'Observatoire de Paris | PSL
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