Exploring the Mysteries of the Universe with Lunarc

Alexey Bobrick

On behalf of the Lunarc users at Lund Observatory, with contributions by: Noemi Schaffer, Alessandra Mastrobuono-Battisti, Abbas Askar, Michiel Lambrechts, Oscar Agertz and Gregor Traven

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Diversity in Astronomy



Credit: Pablo Carlos Budassi

- Spatial scales: from micrometers to trillions of light years
- Timescales: from milliseconds to Gigayears
- Numbers of objects: from a few to trillions
- Models/interactions: similarly broad/diverse



How did the Milky Way form?



Vintergatan Simulation. Credit: Oscar Agertz

- RAMSES Code: Hydrodynamics, stellar populations, feedback ++
- Massively parallel, MPI-enabled
- Resource and memory-demanding
- Longer/heavier jobs on other dedicated clusters



Milky Way Nuclear Star Cluster



UNIVERSITY

- Direct N-body modelling with phiGRAPE, NBSymple codes
- Hundreds of thousands of stars
- GPU and OpenMP-parallel
- Month-long jobs on single nodes

Seeding the Central Supermassive Black Hole

Time =0



- Direct N-body modelling with NBody6++ code
- Hundreds of thousands of stars
- Hybrid parallelisation: MPI, GPU, OpenMP, AVX/SSE
- Several week/months-long jobs



How Did the Solar System Form?



Credit: Noemi Schaffer

- Protoplantary disc hydrodynamics+
 + with MPI Pencil code
- 16-256 cores for up to a few weeks
- Python/IDL post-processing

Credit: Michiel Lambrechts

- N-body code GENGA for planetary dynamics
- Hybrid parallelisation: CUDA, GPU-based
- Several days to several-weeks- UNIVERSITY long jobs



Analysing Spectra of Binary Stars With Machine Learning



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- Disentangling binary spectra
- Python-coupled machine learning codes, e.g. The Cannon
- Large node-bundled parallel grids with 20-30 nodes at a time

Making Type 1a Supernovae



Credit: Alexey Bobrick

- OpenMP-based hydrodynamics with Water code
- Nuclear post processing with large grids of serial job
- Few days to few months long



Summary

We are actively using Lunarc for:

- Serial grids, OpenMP, MPI, GPU jobs
- Code development, including using debug, IDE software and the virtual desktop
- Varied computational needs
- Excellent technical support ++



Astronomer's wish list:

- More and newer GPUs, e.g. A100
- More storage space
- Longer walltimes
- Faster/newer CPUs
- OpenMP-optimised nodes more cores/memory per node



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Lund Astronomy Strongly Benefits from the Versatility of the Lunarc Cluster



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