

# Porting an Asteroseismology Code on GPU thanks to MAGMA library

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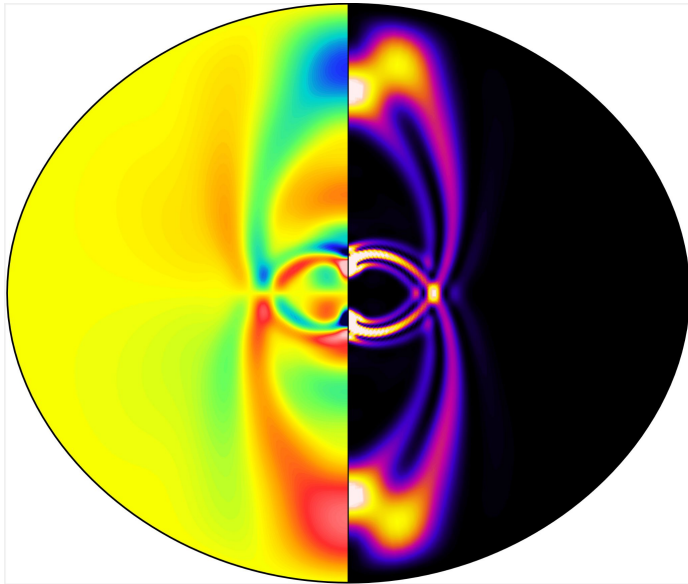
Alejandro Estaña, Daniel Reese, François Ligneres & Jérôme Ballot



# Objective: Accelerate TOP (Two-dimensional Oscillation Program)

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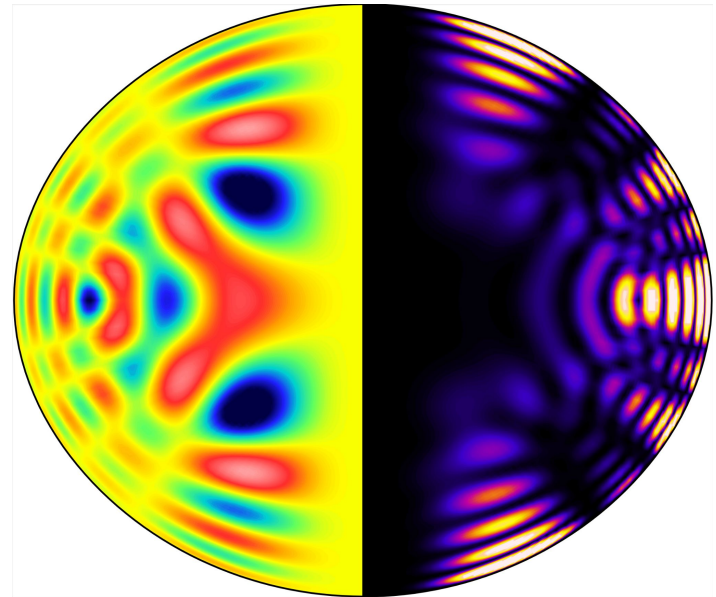
Rosette mode



Pressure fluctuations

Kinetic energy

Chaotic mode



Pressure fluctuations

Kinetic energy

Objective:

## Accelerate TOP (Two-dimensional Oscillation Program)

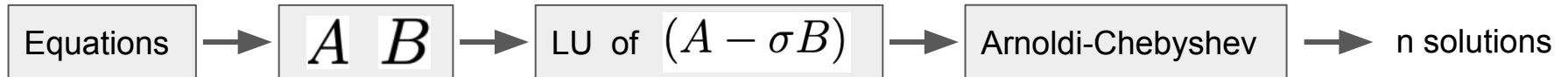
Pulsation equations

$$\begin{aligned}\lambda\rho &= -\vec{v} \cdot \vec{\nabla}\rho_o - \rho_o \vec{\nabla} \cdot \vec{v}, \\ \lambda\rho_o\vec{v} &= -\vec{\nabla}p + \rho\vec{g}_o - \rho_o\vec{\nabla}\Psi - 2\Omega\vec{e}_z \times \rho_o\vec{v}, \\ \lambda p - \lambda c_o^2\rho &= \frac{\rho_o N_o^2 c_o^2}{\|\vec{g}_o\|^2} \vec{v} \cdot \vec{g}_o, \\ 0 &= \Delta\Psi - \rho.\end{aligned}$$

Differential equations expressed in the form of a generalized eigenvalue problem

$$Av = \lambda Bv$$

$$(A - \sigma B)^{-1} Bw = \mu w$$

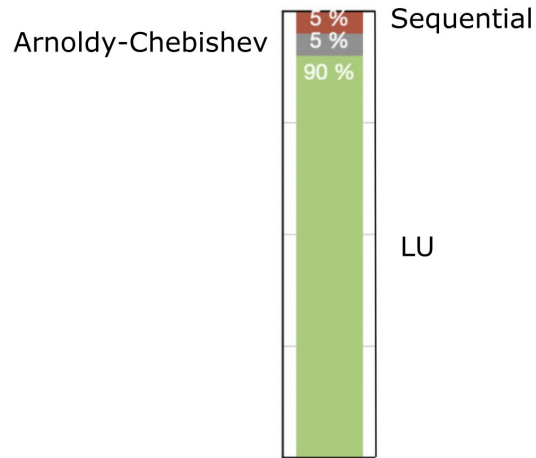


Using **LAPACK** for linear algebra computations

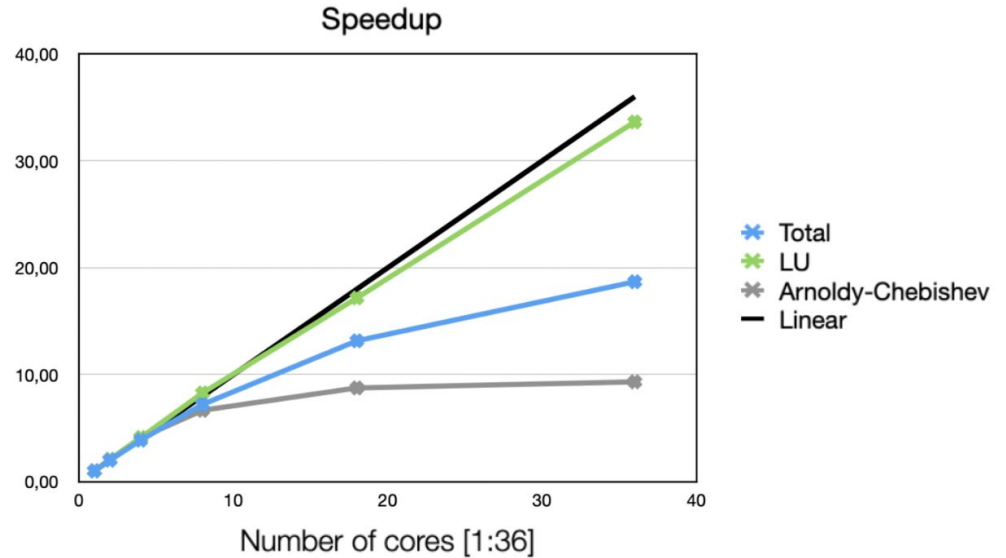
# Actual state of the code

$$\text{Speedup} = \frac{\text{Elapsed time 1 thread}}{\text{Elapsed time N thread}}$$

% Execution time



LAPACK by MKL multithreaded



# Is there a faster alternative to LAPACK?

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**ScaLAPACK** has been tested and it was slower than LAPACK

Libraries that use GPUs:

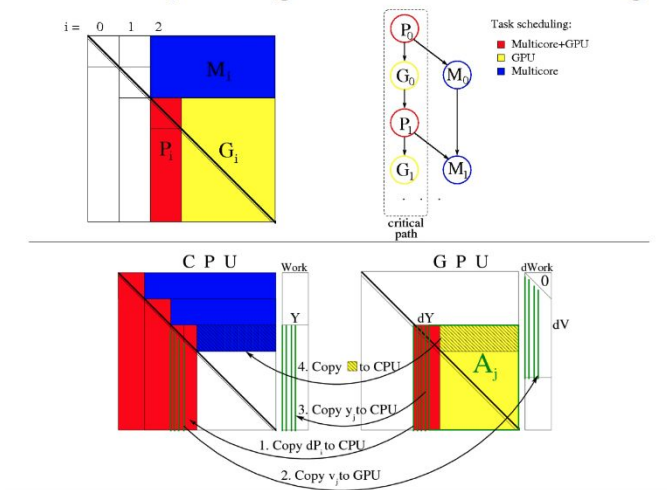
SLEPc, MUMPS, cuSOLVER and **MAGMA**

What is

# MAGMA

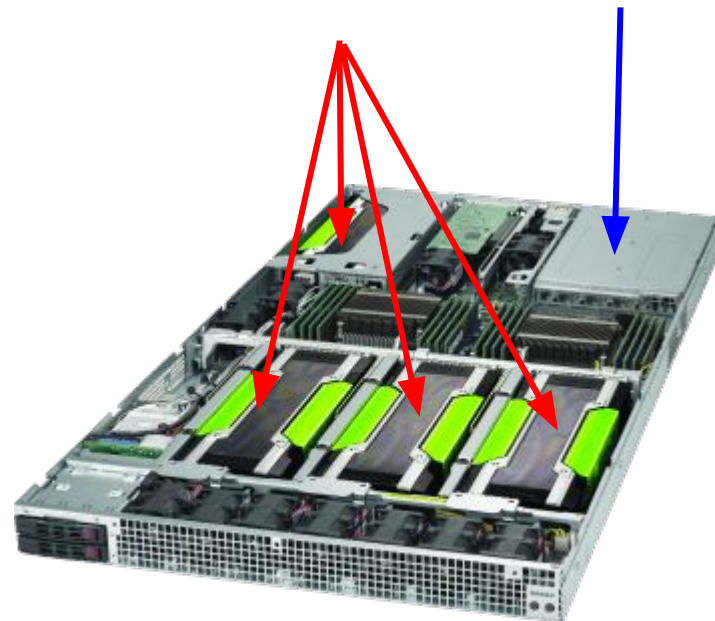
?

## Task Splitting & Task Scheduling



4 GPUs

1 CPU



```
call DGETRF(matrix_dimX, matrix_dimY, matrix, d_dim, piv_vector, info_lapack)
call magmaf_dgetrf(matrix_dimX, matrix_dimY, matrix, d_dim, piv_vector, info_lapack)
```

# MAGMA was not installed in CALMIP

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Mini-project with Atos



Nicolas Renon  
Emmanuel Courcelle

# Atos



Christophe Berthelot  
Paul Karlshoefer



Me

# The project start

## Planning

- 1) Installation of MAGMA using **intel-MKL** and **gnu-OpenBlas**
- 2) Create simple MAGMA examples written in **Fortran** and **C**
- 3) Change TOP code to use MAGMA. Compiling TOP with MAGMA

First day



18 / 02 / 2021

09 / 07 / 2021



# One month later

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Everything works and speedup tests look good !

One month

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Everything works and speedup tests look good !

MAGMA do not work correctly with big matrices ( > 64 Go )



One month

18 / 02 / 2021

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# Testing big matrices

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MAGMA `int( 4 )`:

4 bytes, [-2.147.483.648 : +2.147.483.647]

MAGMA `int( 8 )`:

8 bytes, [-9.223.372.036.854.775.808 : 9.223.372.036.854.775.807]

Simple **examples**



work as expected with `int( 8 )` MAGMA version

**TOP**



is still giving some strange results. WHY ?

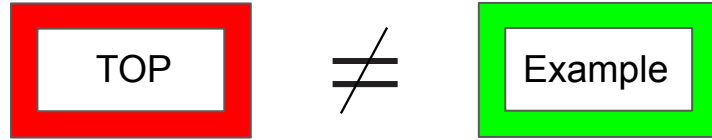
One month

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# Why TOP do not work with MAGMA int8?

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- Checking differences between the examples and TOP

Same flags were used in both cases.

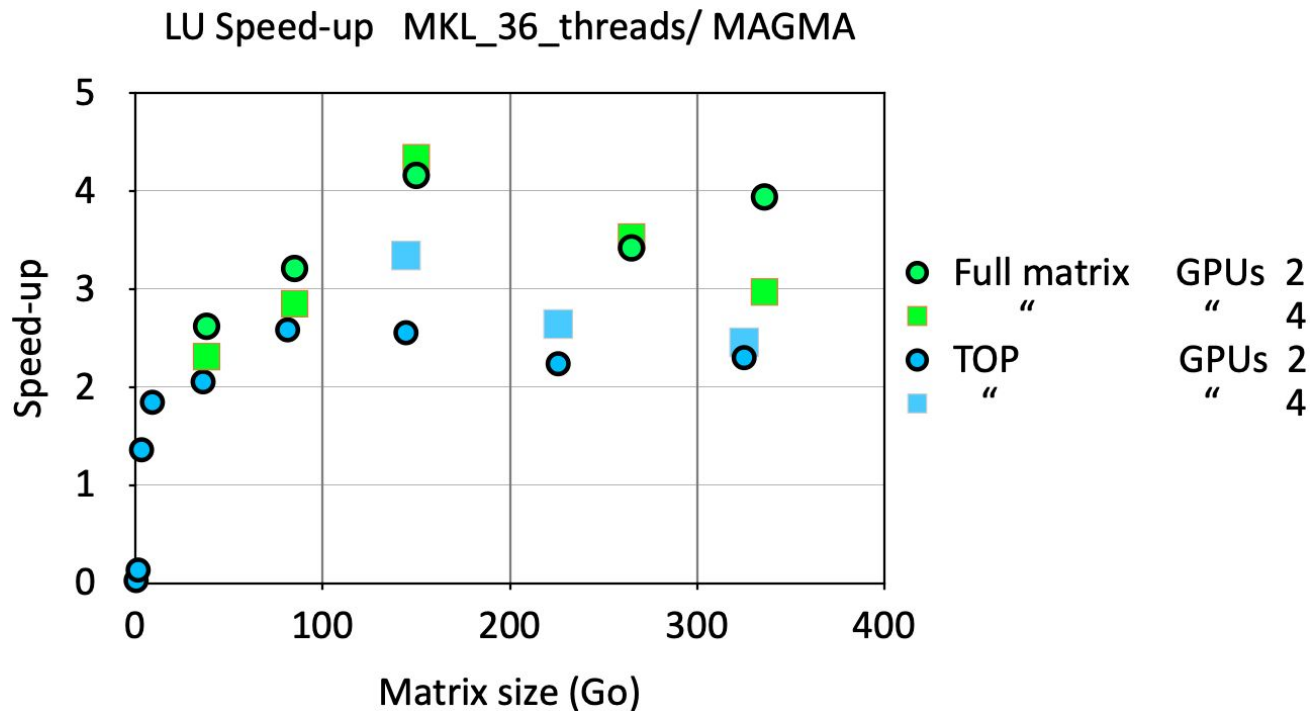
Linked libraries where the same. Checked using “ldd”.

- Contact Marc Gates, MAGMA developer => Change all “int” into “int8” within MAGMA.
- TOP is written in Fortran but it is run from a Python interface thanks to F2PY.



# Speed-up results

2 x (Intel® Skylake 18 coeurs)  
4 x (GP-GPU Nvidia V100)

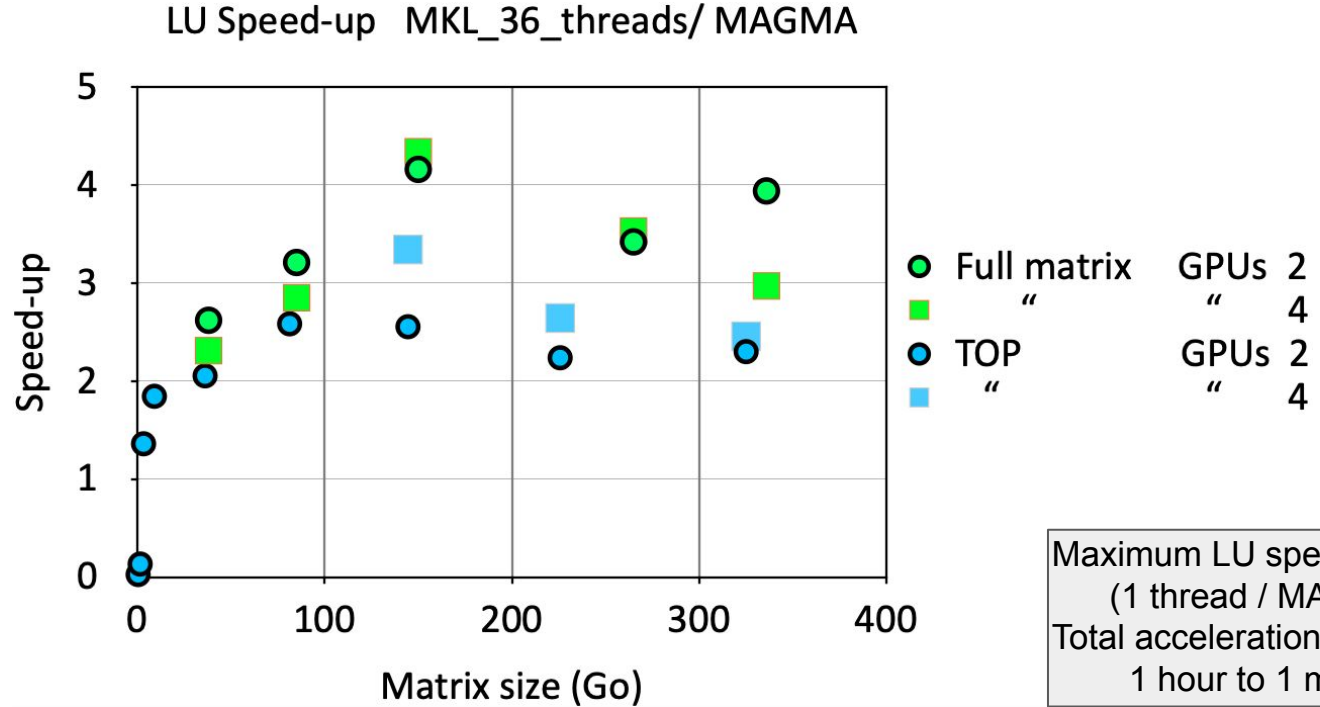


One month

Four months

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One month

Four months

# Conclusion

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- Small bugs can take time to be solved...
- MAGMA is faster on GPU than multi-threaded LAPACK for the tests we performed
- It is easy to move from LAPACK to MAGMA
- Thanks to MAGMA our code is prepared for future hardware changes
- Other codes in LPT & IRAP are going to take advantage from MAGMA

Thank you for your attention