# Accelerating radiative transfer code in black holes with OpenACC in GPU

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## Objective

When a celestial body approaches the gravitational field of a black hole, it can be captured and dismantled into smaller particles that spiral around the black hole in a structure composed of diffuse material or gas called the 'accretion disk'. This structure is of great interest because its characteristics can tell a lot about the black holes to which they belong. The software grmonty, developed at the University of Illinois, simulates the pathways of photons emitted by an accretion disk to observe the electromagnetic spectrum emitted by the disk. This work consists of accelerating grmonty using GPU, through the OpenACC specification, in addition to producing a battery of tests.

## Materials and Methods

Accelerating grmonty's code proved to be a challenging process: there were many global variables, which should be sent to the GPU; some recursive functions caused error during execution on the GPU (possibly because of execution stack overflow); the code used GSL, a GNU library not available on GPU; etc. In addition, it was necessary to produce some tests to refute the initial hypothesis that there could be a race condition in the original code, as well as an end-to-end validation test, to ensure the correctness of the accelerated code. The functions related to GSL random numbers were ported to GPU with OpenACC and recursive functions were transformed and/or simplified into iterative.

## Results

At this time, the accelerated code is still in development. The main functionality not yet implemented is the scattering of the photons. But it is already possible to run a draft version and compare it to the original code also with scattering disabled. The figure below shows the time of 10 executions of both versions, with 100000 photons. The original version was run with 8 threads on an Intel i7-7700HQ 2.80GHz (4 cores with hyper-threading), 16GB RAM, with Manjaro Linux OS. The accelerated version was run on an NVIDIA GeForce GTX1080, with 8GB of memory, Intel i5-8400 2.80GHz, 16GB of RAM and Ubuntu 16.04 system.

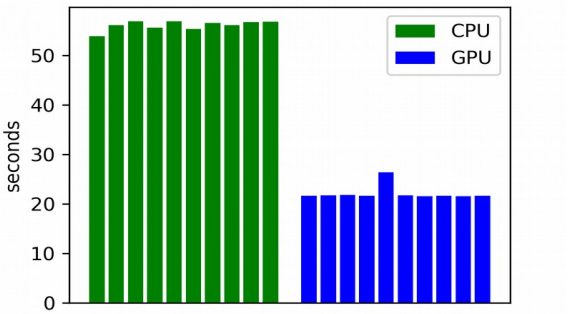


Figure 1: Original and accelerated version time

## Conclusions

Although not yet complete, the accelerated version with OpenACC is already 2.53 times faster than the original version with the same functionalities implemented. And the automated test implemented, validates its correctness.

## References

Dolence, J.C., Gammie, C.F., Mo\'scibrodzka, M., \& Leung, P.-K. 2009, Astrophysical Journal Supplement, 184, 387