**Blue Waters Petascale Semester Curriculum v1.0**

**Unit 4: OpenMP**

**Lesson 1: Race Conditions**

**References / Further Reading**

*Developed by David P. Bunde for the Shodor Education Foundation, Inc.*



*Except where otherwise noted, this work by The Shodor Education Foundation, Inc. is licensed under CC BY-SA 4.0. To view a copy of this license, visit*[*https://creativecommons.org/licenses/by-sa/4.0*](https://creativecommons.org/licenses/by-sa/4.0)

*Browse and search the full curriculum at*[*http://shodor.org/petascale/materials/semester-curriculum*](http://shodor.org/petascale/materials/semester-curriculum)

*We welcome your improvements! You can submit your proposed changes to this material and the rest of the curriculum in our GitHub repository at*[*https://github.com/shodor-education/petascale-semester-curriculum*](https://github.com/shodor-education/petascale-semester-curriculum)

*We want to hear from you! Please let us know your experiences using this material by sending email to* [*petascale@shodor.org*](mailto:petascale@shodor.org)

Background on the Mandelbrot set (Wikipedia page):

<https://en.wikipedia.org/wiki/Mandelbrot_set>

This lesson is based on the second module from the following:

D.P. Bunde. “Modules for introducing threads”. In Prasad, Gupta, Sussman, and Weems editors, *Topics in parallel and distributed computing: Introducing concurrency in undergraduate courses*, chapter 4, pages 59-82, Morgan Kaufmann, 2015.

<https://tcpp.cs.gsu.edu/curriculum/?q=system/files/ch4.pdf>

That lesson shows the first kind of race conditions as we do here. It does not cover reductions, but does show load balance and loop scheduling. It creates a .bmp file instead of a .ppm file. Using .bmp causes the race condition to cause color differences, but the file format is significantly more complicated.