



HAL
open science

Radiative, conductive and convective heat-transfers in a single Monte Carlo algorithm

Richard A Fournier, Stéphane Blanco, Vincent Eymet, Mouna El-Hafi,
Christophe Spiesser

► **To cite this version:**

Richard A Fournier, Stéphane Blanco, Vincent Eymet, Mouna El-Hafi, Christophe Spiesser. Radiative, conductive and convective heat-transfers in a single Monte Carlo algorithm. *Journal of Physics: Conference Series*, 2016, 676 (1), art. 012007 - 3 p. 10.1088/1742-6596/676/1/012007 . hal-01706727

HAL Id: hal-01706727

<https://imt-mines-albi.hal.science/hal-01706727>

Submitted on 22 Mar 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

PAPER • OPEN ACCESS

Radiative, conductive and convective heat-transfers in a single Monte Carlo algorithm

To cite this article: Richard Fournier *et al* 2016 *J. Phys.: Conf. Ser.* **676** 012007

View the [article online](#) for updates and enhancements.

Related content

- [Venus Ly: A Morphological and Radiative Transfer Analysis](#)
William B. Colwell
- [Radiative cooling of hot Cn- and CnH- molecules](#)
M Kaminska, R F Nascimento, M H Stockett *et al.*
- [Radiative heat transfer in plasma of pulsed high pressure caesium discharge](#)
V F Lapshin

Radiative, conductive and convective heat-transfers in a single Monte Carlo algorithm

Richard Fournier^{a,b}, Stéphane Blanco^{a,b}, Vincent Eymet^c, Mouna El Hafî^d, Christophe Spiesser^d

^a Université de Toulouse ; UPS, INPT ; LAPLACE (Laboratoire Plasma et Conversion d'Énergie) ; 118 route de Narbonne, F-31062 Toulouse cedex 9, France.

^b CNRS ; LAPLACE ; F-31062 Toulouse, France.

^c Méso-Star SAS, 8 rue des pêcheurs, 31410 Longages, France

^d Université de Toulouse, Mines-Albi, UMR-CNRS 5302, Centre RAPSODEE, Campus Jarlard, F-81013 Albi CT cedex 09, France

E-mail: richard.fournier@laplace.univ-tlse.fr

Abstract. It was recently shown that null-collision algorithms could lead to grid-free radiative-transfer Monte Carlo algorithms that immediately benefit of computer-graphics tools for an efficient handling of complex geometries [1, 2]. We here explore the idea of extending the approach to heat transfer problems combining radiation, conduction and convection. This is possible as soon as the model can be given the form of a second-kind Fredholm equation. In the following pages, we show that this is quite straightforward at the stationary limit in the linear case. The oral presentation will provide corresponding simulation examples. Perspectives will then be drawn concerning the extension to non-stationary cases and non-linear coupling.

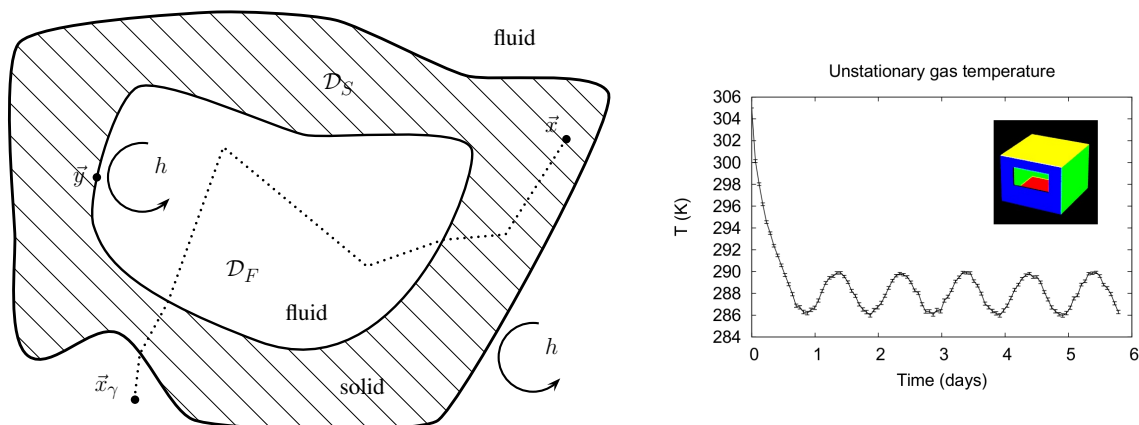


Figure 1. Fluid and solid domains (left). Academic example of a Monte Carlo simulation dealing with radiative, conductive and convective heat-transfers, for opaque solids and transparent fluids (internal air-temperature for a sinusoidal external forcing, right).

as the expectation of a random function $\Theta(\vec{x})$. The Monte Carlo algorithm then evaluates $\theta(\vec{x})$ as the average of a large number of Θ samples [3]. The definition of Θ combines six random functions of location: A_N , A_R and A_{NC} for the selection a source type (incoming flow, radiation or convection), \vec{X}_G for the sampling of a location within the solid or fluid domain, \vec{Y}_G for sampling of a location at the boundary and Θ_R that samples of an optical path and returns the temperature at its extremity.

$$\Theta(\vec{x}) = A_N(\vec{x})\theta_N + A_R(\vec{x})\Theta_R(\vec{X}_G(\vec{x})) + A_C(\vec{x})\theta_C(\vec{Y}_G(\vec{x})) \left. \vphantom{\Theta(\vec{x})} \right\} \text{solid or fluid} \quad (7)$$

As $\Theta_R(\vec{X}_G(\vec{x}))$ and $\theta_C(\vec{Y}_G(\vec{x}))$ involve the solid and fluid temperatures at random locations, these temperatures can again be replaced by the expectation of Θ at the corresponding locations and the Monte Carlo algorithm becomes recursive, just as for simulation of multiply scattered radiation. The algorithm stops when the required temperature is known, either because this corresponds to the incoming flow and θ_N is known, or because the sampled location is at the boundary. This recursivity is a typical consequence of the combination of equations 4, 5 and 6 leading to a second-kind Fredholm equation.

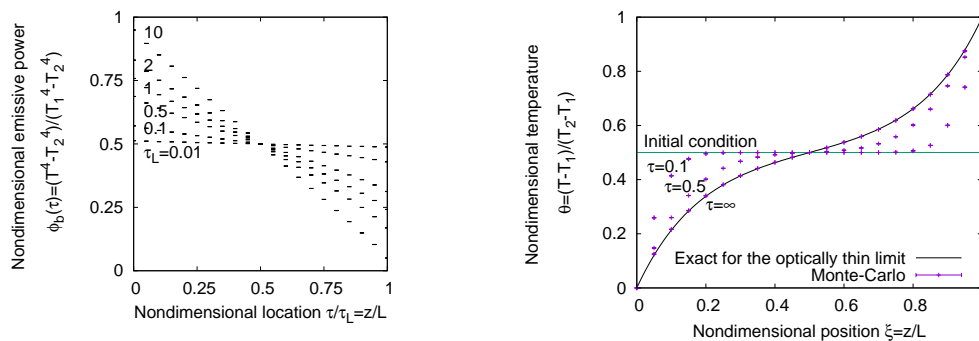


Figure 2. Academic 1D examples involving semi-transparent solids: radiative “equilibrium” (left); radiation coupled with non-stationnary conduction (right). Notations are from [4] page 460 and page ??.

- [1] Galtier M, Blanco S, Caliot C, Coustet C, Dauchet J, El Hafi M, Eymet V, Fournier R, Gautrais J, Khuong A, Piaud B and Terree G 2013 *J. Quant. Spectr. Rad. Transfer* **125** 57–68 ISSN 0022-4073
- [2] Eymet V, Poitou D, Galtier M, El Hafi M, Terree G and Fournier R 2013 *J. Quant. Spectr. Rad. Transfer* **129** 145–157 ISSN 0022-4073
- [3] Delatorre J, Baud G, Beziau J J, Blanco S, Caliot C, Cornet J F, Coustet C, Dauchet J, El Hafi M, Eymet V, Fournier R, Gautrais J, Gourmel O, Joseph D, Meilhac N, Pajot A, Paulin M, Perez P, Piaud B, Roger M, Rolland J, Veynandt F and Weitz S 2014 *Solar Energy* **103** 653–681 ISSN 0038-092X
- [4] Modest M F 1993 *Radiative Heat Transfer* (McGraw-Hill, Inc.)