New Monte Carlo code for solving radiative transfer equations

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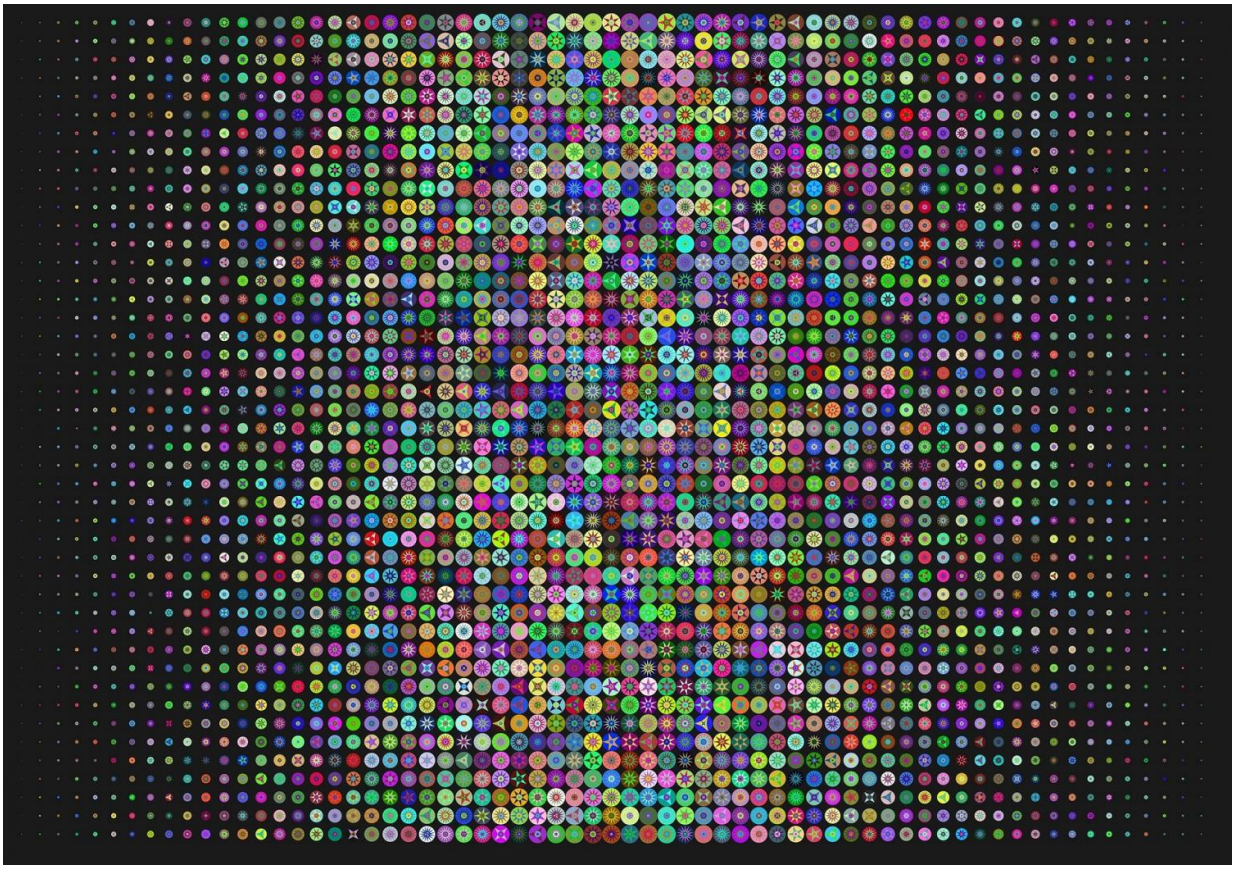

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Recently, YANG Xiaolin and his collaborators from Yunnan Observatories of the Chinese Academy of Sciences developed a new fast code, Lemon (Linear Integral Equations' Monte Carlo Solver Based on

Neumann Solution), aiming to solve the radiation transfer processes (RTPs) precisely. The scheme of the code is based on linear integral equation and its Neumann series solution. The study was published in The *Astrophysical Journal Supplement* Series.

RTs are the most primary and omnipresent physical processes in the field of astrophysics, and they play an important role both in theoretical researches and practical observations. To solve RTs, various methods have been proposed, among which the Monte Carlo (MC) method is the most important and widely used numerical method due to its simplicity yet powerful and remarkable performances.

The conventional MC method (or photon tracing scheme), however, has an intrinsic defect that is the large amount of computations usually produce a result with quit low statics and large variance, since a significant portion of the computational cost are totally wasted.

In order to overcome the defect, Yang Xiaolin and his collaborators proposed a new scheme, in which they suggested that the MC method employed to solve the RTs should be built on the integral equation and its Neumann solution rather than photon tracing.

The new scheme has major advantages. It can compel the photons to make contributions to the results at each scattering site, significantly improving the calculation efficiency and accuracy. As a result, the defect is overcome or alleviated. It can treat the RTs with and without polarizations in a unified framework and simplify the computation procedure if the geometric configuration of the system has an axial or spherical symmetry. Additionally, it can be applied directly to solve any linear differential-integral equations with initial or boundary conditions appropriately provided.

Lemon is developed completely on this new scheme and written in

FORTRAN 90 language. It is publicly available and can be downloaded from: github.com/yangxiaolinyn/Lemon. At present, Lemon can solve the problems of RTs mainly restricted to flat space-time. To increase the computing speed, Lemon implements the simplest parallel computation by adopting the Message Passing Interface (MPI) scheme.

The validation of Lemon has been verified by reproducing the results of several test problems. One can find that Lemon is characterized by fast speed, flexibility in computational methods, high efficiency and accuracy, which guarantees the potential applications of Lemon for the calculations of RTs in the future.

More information: Yang Xiao-lin et al, A New Fast Monte Carlo Code for Solving Radiative Transfer Equations Based on the Neumann Solution, *The Astrophysical Journal Supplement Series* (2021). DOI: 10.3847/1538-4365/abec73

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