Wave-optical toolbox for multiple CRL transfocators

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Wave-optical simulation toolbox for transfocators

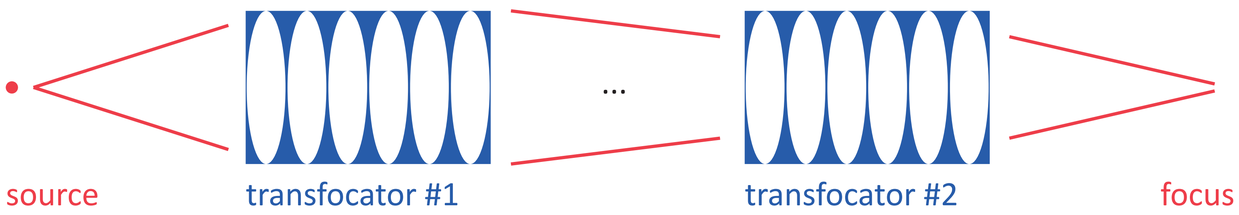
We are developing a toolbox for wave-optical simulations of x-ray transfocators.

Transfocators are arrays of compound refractive lenses [1]; they are modular and the number of active lenses can be changed automatically within seconds. This allows for easy adjustment of focal length (i.e. working distance) and photon energy (dispersive optics) [2].

New set-ups rely on *multiple transfocators*, e.g. for pre-focusing and collimation of the beam. While a single lens usually can be treated as a *thin object*, described by its complex transmission function, this would be oversimplified in the case of a complete transfocator containing, e.g. 128 lenses [2].

With our new code, these new set-ups can be simulated. The project is ongoing and the code is not yet available.

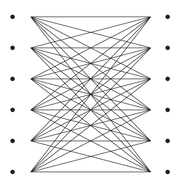
Geometry



so far, a monochromatic *point-source* is assumed,
but generalisation towards *partially coherent propagation* is possible with our external code [3,4] that uses the method of stochastic superpositions.

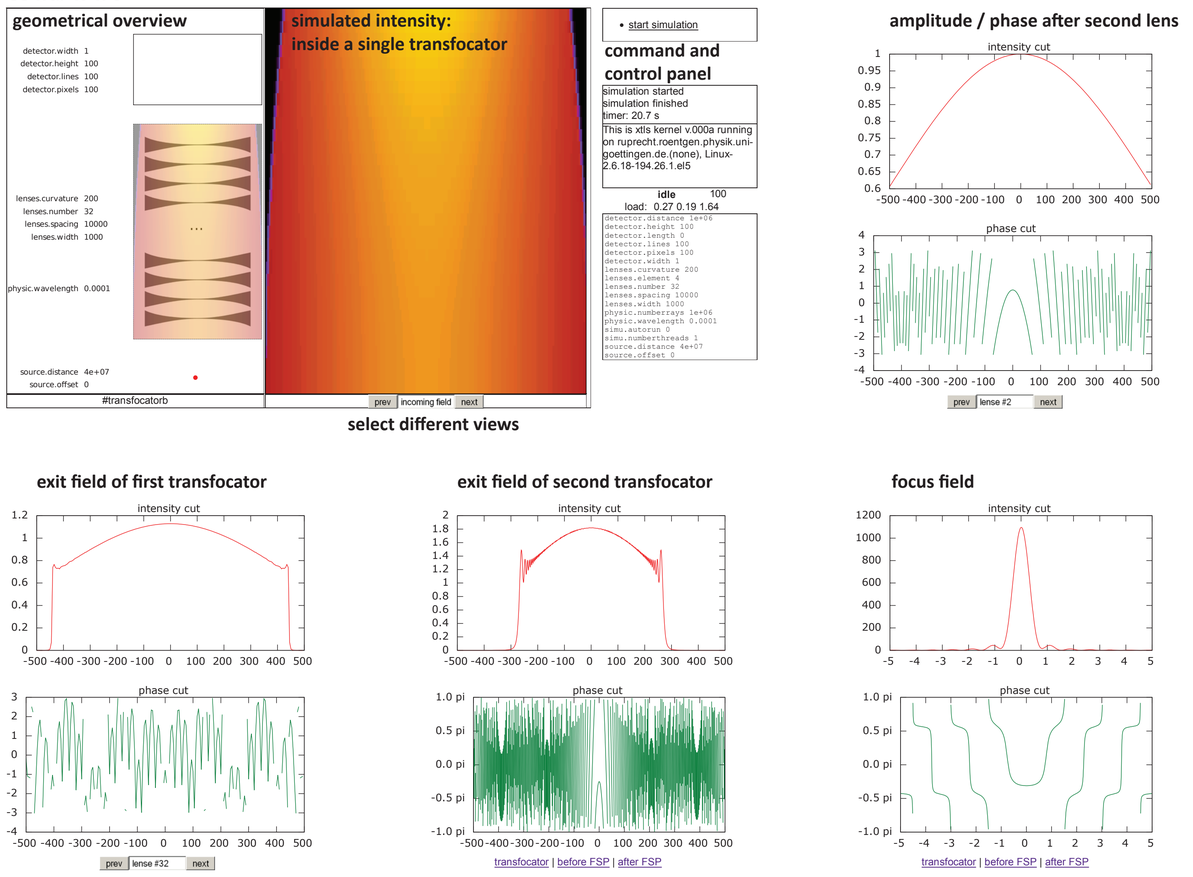
Thin lens approximation
- each lens is modelled by a complex transmission function $e^{-i\frac{k\Delta y^2}{2f}}$
- propagation between lenses: Fourier methods
- complex wave field at transfocator's exit

Free space propagation
- from exit to entrance: Fresnel-Kirchhoff integral
- massive parallelism using CUDA graphics cards
- Fourier methods: not applicable due to sampling



$\int \psi\, e^{i k \cdot x}$

webGUI



What XTLS currently can:
- propagate a monochromatic point-source through a sequence of transfocators
- perfect lenses, ideal alignment
- study complex-valued field for each lens

Under development:
- generalisation: spatially partial coherence
- misaligned or tilted lenses, surface roughness, polychromaticity, etc.

Future plans:
- API to third-party software
- improved online-analysis tools

space for your ideas:

X-ray Transfocator Lenses Simulation: basics

-high-performance C++ code, command line interface and graphical webGUI
-massively parallel computing on graphics card
-two modules:

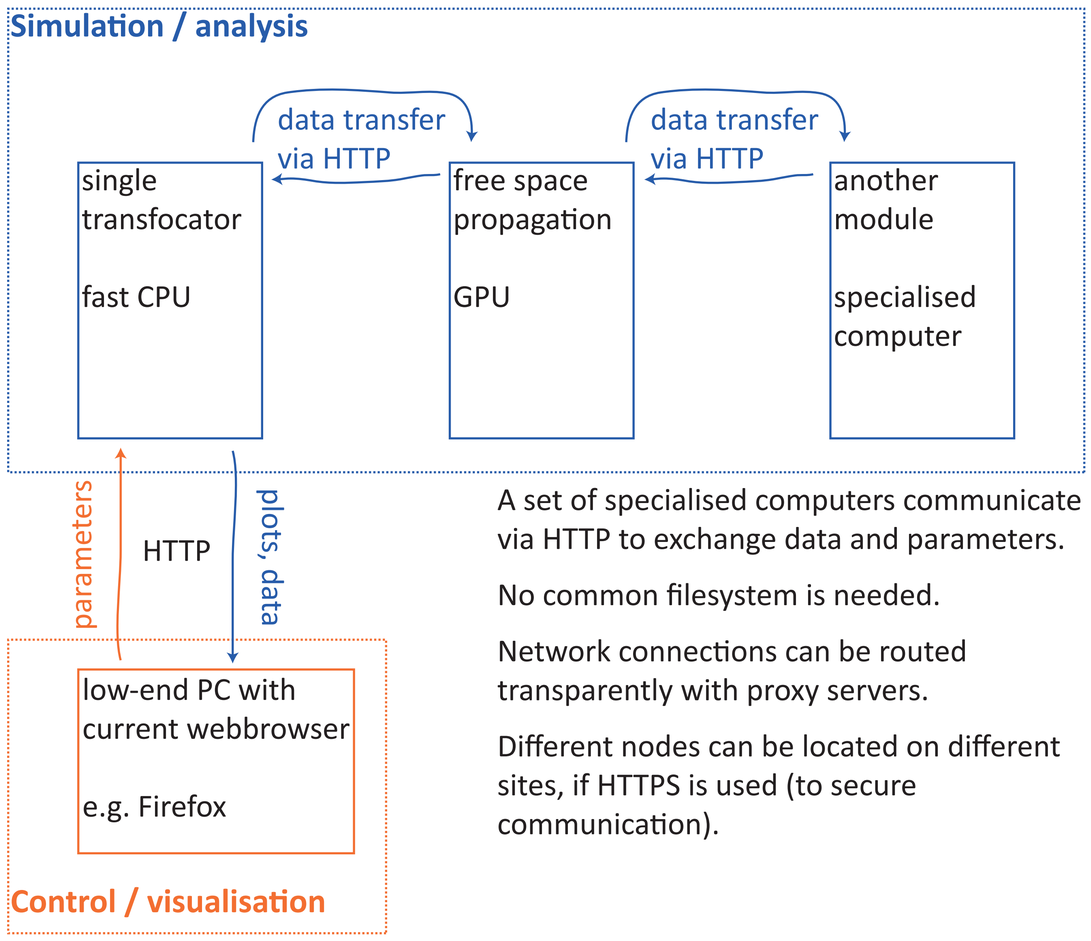
Single Transfocator
- propagates x-ray field through array of identical lenses
- incoming field: either a point-source or propagated field of...

Free Space Propagator
- propagates x-ray field from one transfocator to the next

Communication
-propagated field is communicated via HTTP, so no common file system necessary; only internet access needed (proxy, HTTPS, authentication possible)

-both modules controllable with one common webGUI

Distributed computing



A set of specialised computers communicate via HTTP to exchange data and parameters.

No common filesystem is needed.

Network connections can be routed transparently with proxy servers.

Different nodes can be located on different sites, if HTTPS is used (to secure communication).

Low-end computers are used for control and visualisation.

The simulation cluster can be remote-controlled from *anywhere* (on the internet).

Nowerdays, browsers are capable of major visualisation techniques, even 3D.

Summary
- A new wave-optical simulation tool to model multiple x-ray transfocators is under development.

Outlook
- more realistic model, including: lens tilts, misalignments, surface errors
- API to call the programme externally (i.e. Python, Matlab etc.)
- partial coherence

Related publications

References

[1] A. Snigirev, V. Kohn, I. Snigireva, B. Lengeler, Nature 384 (1996).
[2] G. B. M. Vaughan, J. P. Wright, A. Bytchkov, M. Rossat, H. Gleyzolle, I. Snigireva, A. Snigirev, J. Synchrotron Rad. 18 (2011).
[3] M. Osterhoff, T. Salditt, New Journal of Physics 13 (2011).
[4] M. Osterhoff, T. Salditt, Proc. SPIE 8141 (2011).