华中科技大学引力实验中心
CENTER FOR GRAVITATIONAL EXPERIMENTS

Development of Optical Simulation Software for Ultra-Stable Optical Bench Fabrication

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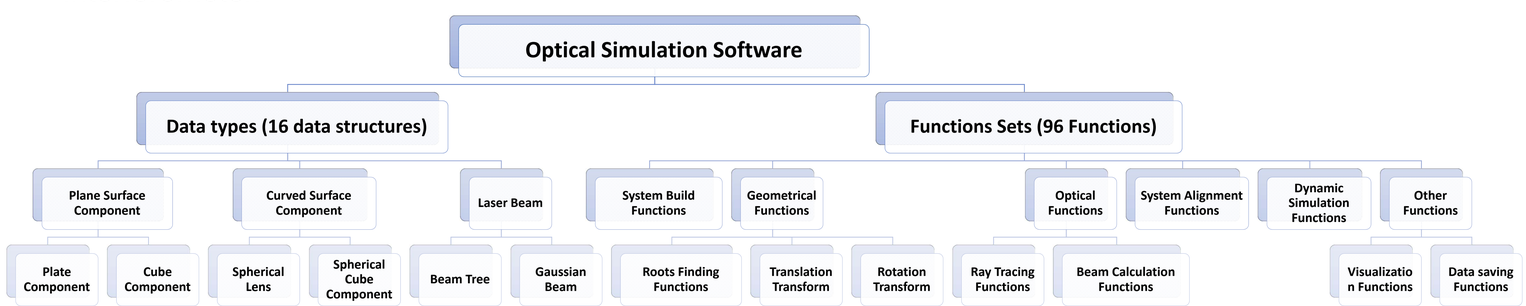
Why do we need a 3-D interferometer simulation software?

Motivations:

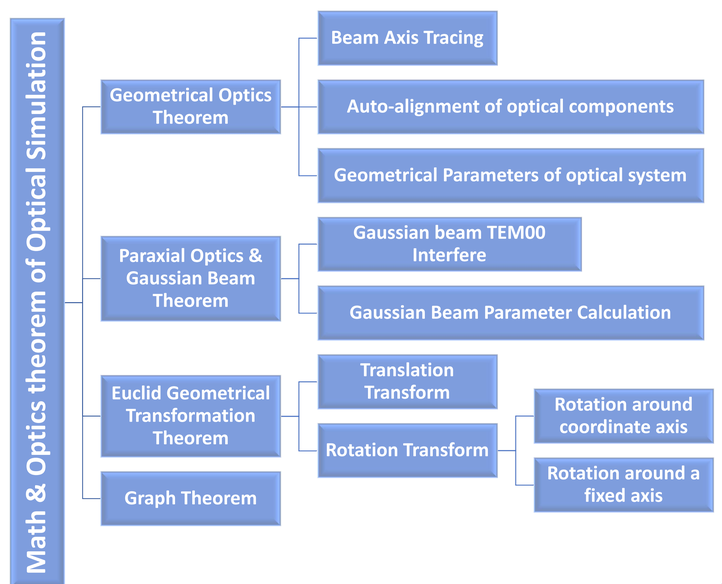
- Analyze satellite altitude jitter-OPL coupling error;
- Analyze thermal-OPL coupling error;
- Analyze vibration effects;
- Calculate components' alignment requirements;
- Get geometrical parameters of Optical Interferometer.

Characteristics:

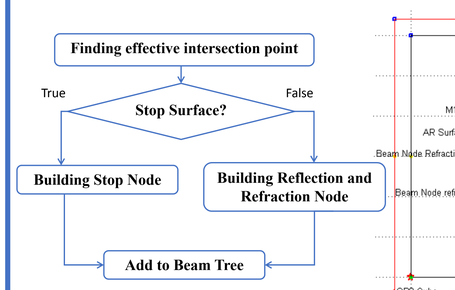
- "OPTICAL SIMULATION" is developed based on MATLAB platform;
- Building 3D Interferometer model;
- Auto-configuration of components;
- Static and dynamic simulation.

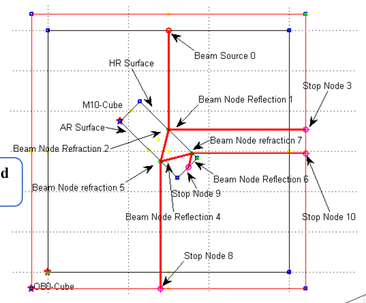


Theorem of Optical Simulation



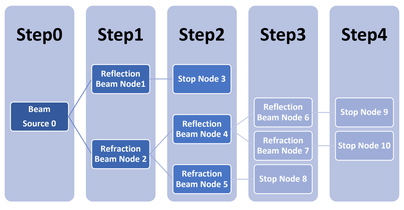
Beam Axis Tracing Arithmetic & Beam Calculation

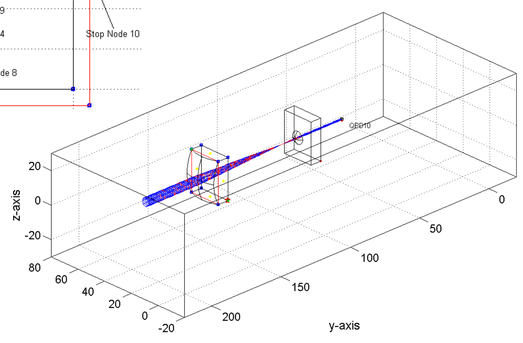




Parameters:

- Fused Silica Components;
- Spherical Lens;
- Focal length: 60 & 10 mm;
- Input laser beam waist 2.5 mm.



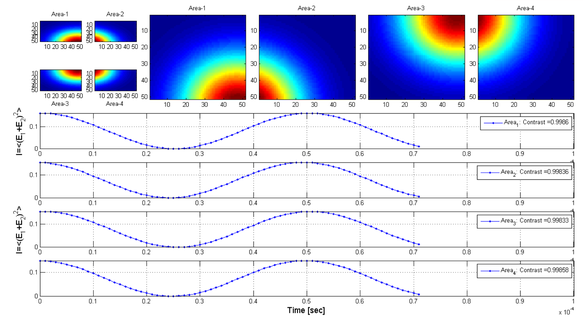


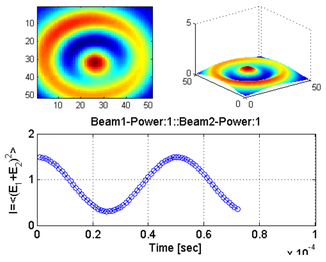
TEM00 Gaussian Beam Interference Calculation

$$\vec{E}(z,\vec{r};t)=\vec{\varepsilon}\sqrt{\frac{2P}{\pi\omega^2(z)}}\exp[-\frac{r^2}{\omega^2(z)}]\exp\{i[\frac{kr^2}{2R(z)}-\eta(z)]\}\exp[i(kz-\omega t)]$$

$$\begin{cases}\vec{E}_1(z_1,r_1;t)=\vec{A}_1(z_1,r_1;t)\exp[i\varphi_1(z_1,r_1;t)]=\vec{a}_1\cdot A_1(z_1,r_1;t)\exp[i\varphi_1(z_1,r_1;t)]\\ \vec{E}_2(z_2,r_2;t)=\vec{A}_2(z_2,r_2;t)\exp[i\varphi_2(z_2,r_2;t)]=\vec{a}_2\cdot A_2(z_2,r_2;t)\exp[i\varphi_2(z_2,r_2;t)]\end{cases}$$

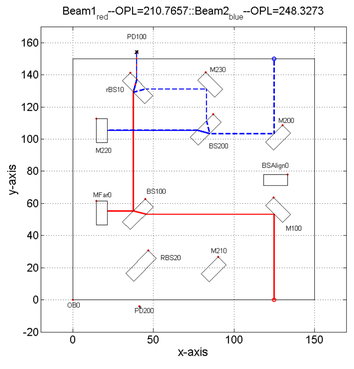
$$I_P=\left\langle E^2\right\rangle=\left\langle\vec{E}_1^2\right\rangle+\left\langle\vec{E}_2^2\right\rangle+2\vec{a}_1\cdot\vec{a}_2\left\langle\vec{E}_1\vec{E}_2\right\rangle\cos(\varphi_1-\varphi_2)\qquad I(t)=\int I_p d\sigma$$



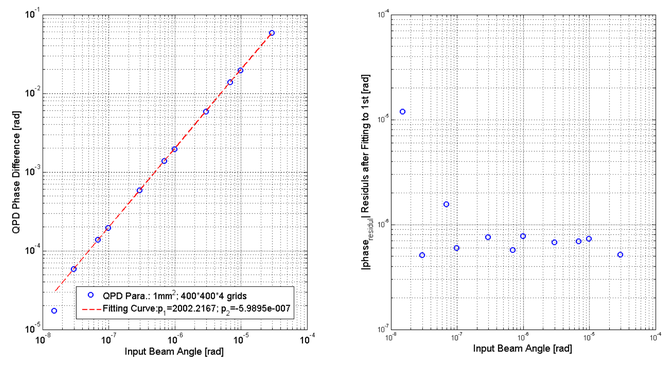


- Calculate the beat signal output by PD or QPD;
- Using PhaseMeter function to get the signal phase.

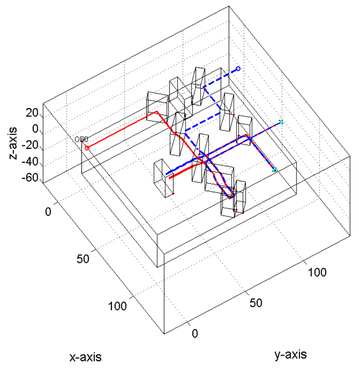
Optical Path Calculation



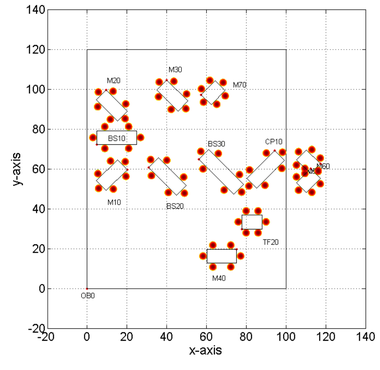
Differential Wave-front Sensing Simulation



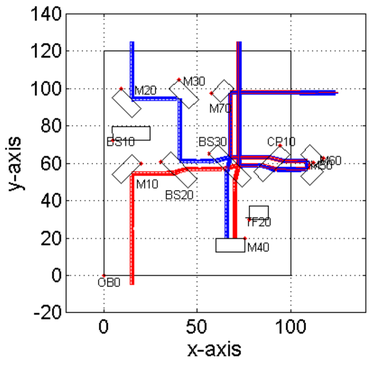
Optical Interferometer Deign



Positioning Ball Coordinates Calculation



Static Simulation



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