

## TEST CASE 2: GPR Scenario

### Backscattered field depending on frequency and angle

Chair: Frank Weinmann, Fraunhofer, FHR

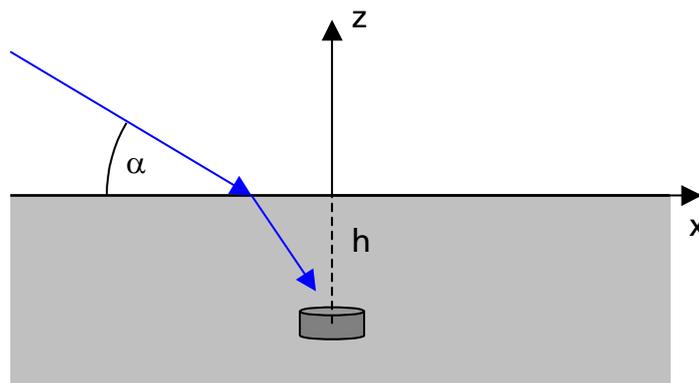
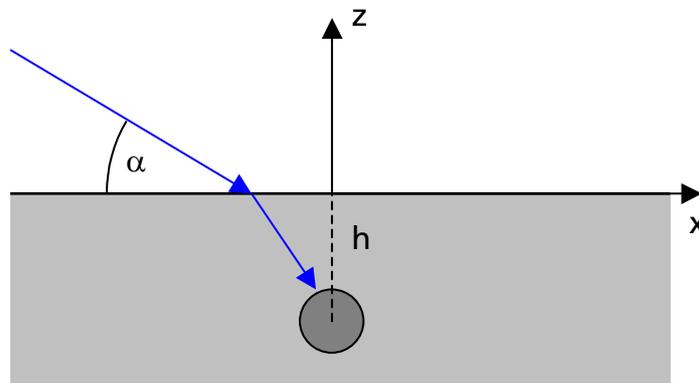
Udo Uschkerat, Fraunhofer FHR

Contact: [frank.weinmann@fhr.fraunhofer.de](mailto:frank.weinmann@fhr.fraunhofer.de)

[udo.uschkerat@fhr.fraunhofer.de](mailto:udo.uschkerat@fhr.fraunhofer.de)

#### 1. Definition of the Geometry

The targets are a sphere of radius  $R_s$  and a cylinder of radius  $R_c$ , respectively, which are located beneath the surface of a dielectric medium (half space) with relative permittivity  $\epsilon_r$ . The distance from the surface to the mass centre of the target is denoted as  $h$ .



#### 2. Simulation Parameters

The time dependency is assumed to be  $\exp(j\omega t)$ . 3D simulation only, no 2D setups.

The dielectric medium is assumed to have the relative permittivity  $\epsilon_r = 4 - j 0.05$ .

The sphere is assumed to be located at  $h = 0.3$  m below the surface of the dielectric medium. The radius of the sphere is  $R_s = 0.1$  m (centre of the sphere at  $(x, y, z) = (0, 0, -0.3)$ ).

The cylinder is assumed to be located at  $h = 0.3$  m below the surface of the dielectric medium. The radius of the cylinder is  $R_c = 0.1$  m and its height is  $h_c = 0.1$  m (mass centre of the cylinder at  $(x, y, z) = (0, 0, -0.3)$ , vertical extension from  $z_{min} = -0.35$  m to  $z_{max} = -0.25$  m).

For the targets described above, the monostatic RCS shall be simulated for a fixed aspect angle in the frequency range 0.3-5.0 GHz. The phase center of Tx/Rx point shall be set to the point  $(x, y, z) = (-1, 0, 0.7)$ .

Depending on the method used for modelling this test case, further assumptions and/or simplifications need to be made, e.g., finite scenario, near-field set-up, etc. – in this case, the simplifications shall be documented in an additional document (see section 4.).

#### *2.1. Case (a): PEC sphere*

The monostatic RCS shall be simulated for a metallic (PEC) sphere. The aspect angle of the incidence wave is  $\alpha = 45^\circ$ . Simulation data shall be calculated for the frequency range 0.3-5.0 GHz,  $\Delta f = 10$  MHz, for both vertical polarisation ( $\theta\theta$ -polarisation, i.e., electric field in the  $xz$ -plane) and horizontal polarisation ( $\phi\phi$ -polarisation, i.e., electric field perpendicular to the  $xz$ -plane). Cross-polarisation is relevant.

#### *2.2. Case (b): dielectric sphere*

The dielectric sphere shall be simulated with the same parameters as in Case (a) using a relative permittivity  $\epsilon_r = 3$  for the sphere.

#### *2.3. Case (c): PEC cylinder*

The PEC cylinder shall be simulated with the same parameters as in Case (a), replacing the sphere by the cylinder and using the parameters described in section 2.

#### *2.4. Case (d): dielectric cylinder*

The dielectric cylinder shall be simulated with the same parameters as in Case (c) using a relative permittivity  $\epsilon_r = 3$  for the cylinder.

#### *2.5. Case (e): bistatic configuration*

Each of the Cases (a) to (d) shall be simulated with a bistatic configuration for a fixed frequency  $f = 3$  GHz and for the reflected angle  $-90^\circ \leq \theta' \leq 90^\circ$ ,  $\Delta\theta' = 0.5^\circ$ , where  $\theta = -90^\circ$  is equivalent to the negative  $x$ -axis and  $\theta = 90^\circ$  is equivalent to the positive  $x$ -axis.

### *3. Data Formats*

The results will be stored in ASCII files, labelled as:

- *test\_case\_2a\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2b\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2c\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2d\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2ea\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2eb\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2ec\_CONTRIBUTOR\_NAME.txt*
- *test\_case\_2ed\_CONTRIBUTOR\_NAME.txt*

where “CONTRIBUTOR\_NAME” should be replaced by the name of the contributing institution, if necessary followed by a postfix indicating the method used for the simulations, e.g., Contributor1\_FDTD, Contributor1\_MoM,...

Each file will contain on each row the data :

$$f \quad \theta \quad \text{Re}(\sigma_{\theta\theta}) \quad \text{Im}(\sigma_{\theta\theta}) \quad \text{Re}(\sigma_{\phi\phi}) \quad \text{Im}(\sigma_{\phi\phi}) \quad \text{Re}(\sigma_{\theta\phi}) \quad \text{Im}(\sigma_{\theta\phi}) \quad \text{Re}(\sigma_{\phi\theta}) \quad \text{Im}(\sigma_{\phi\theta})$$

where  $f$  is the frequency in GHz,  $\theta$  is the angle associated with the observation point,  $\sigma_{\theta\theta}$  and  $\sigma_{\phi\phi}$  are the RCS in dBsm in  $\theta\theta$ -polarisation and  $\phi\phi$ -polarisation.

#### 4. Additional Information

Each *.txt*-file should be accompanied by a *.info*-file, stating additional information relevant for the simulation, e.g., short description of the method used, CPU time, memory usage, number of unknowns, characteristics of simulation hardware (number of cores, processor speed),...