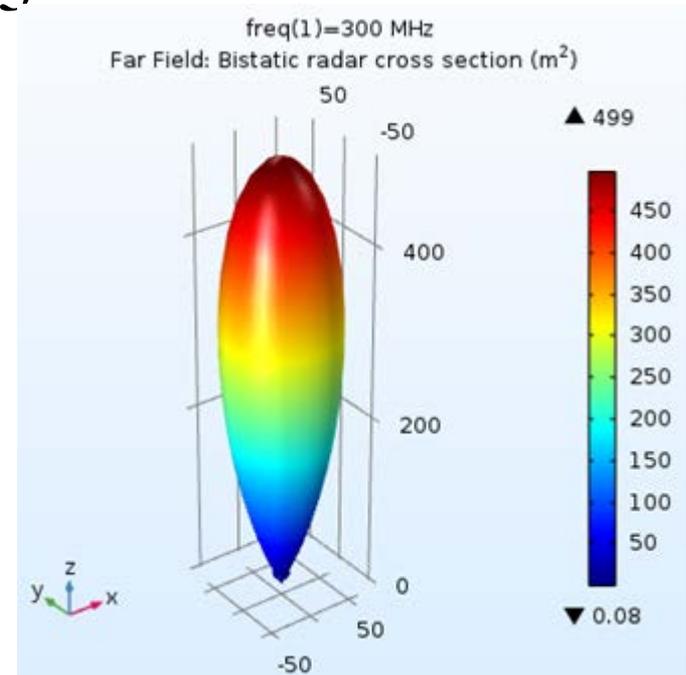
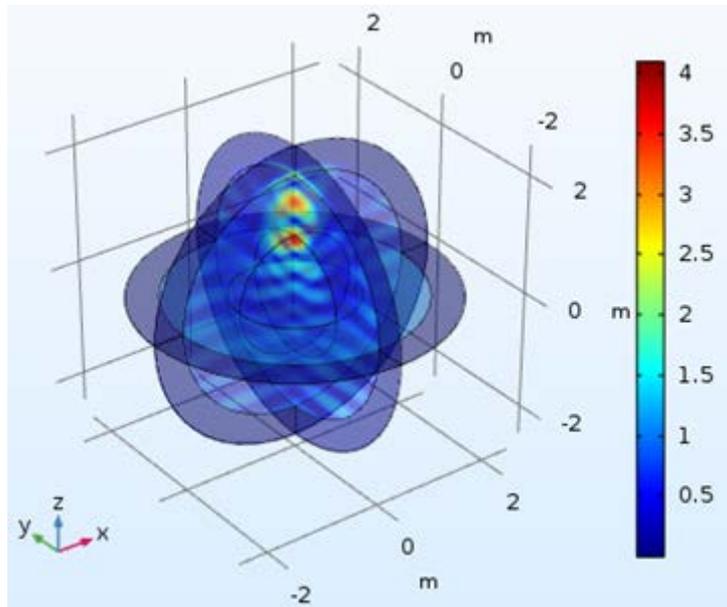
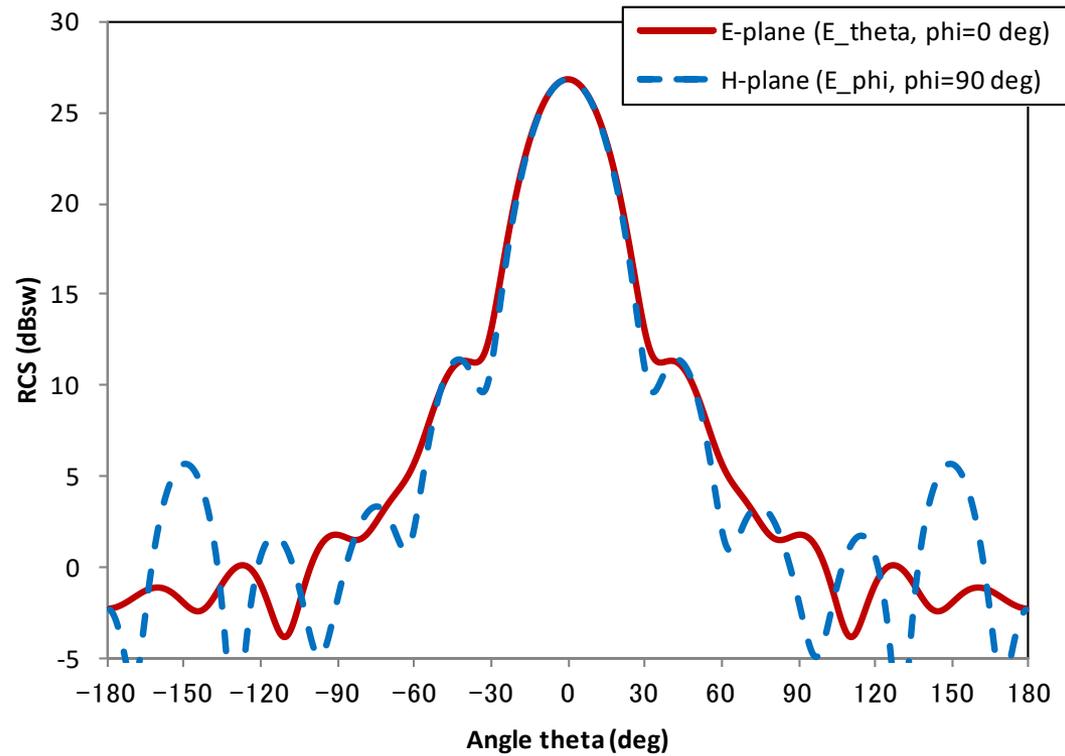
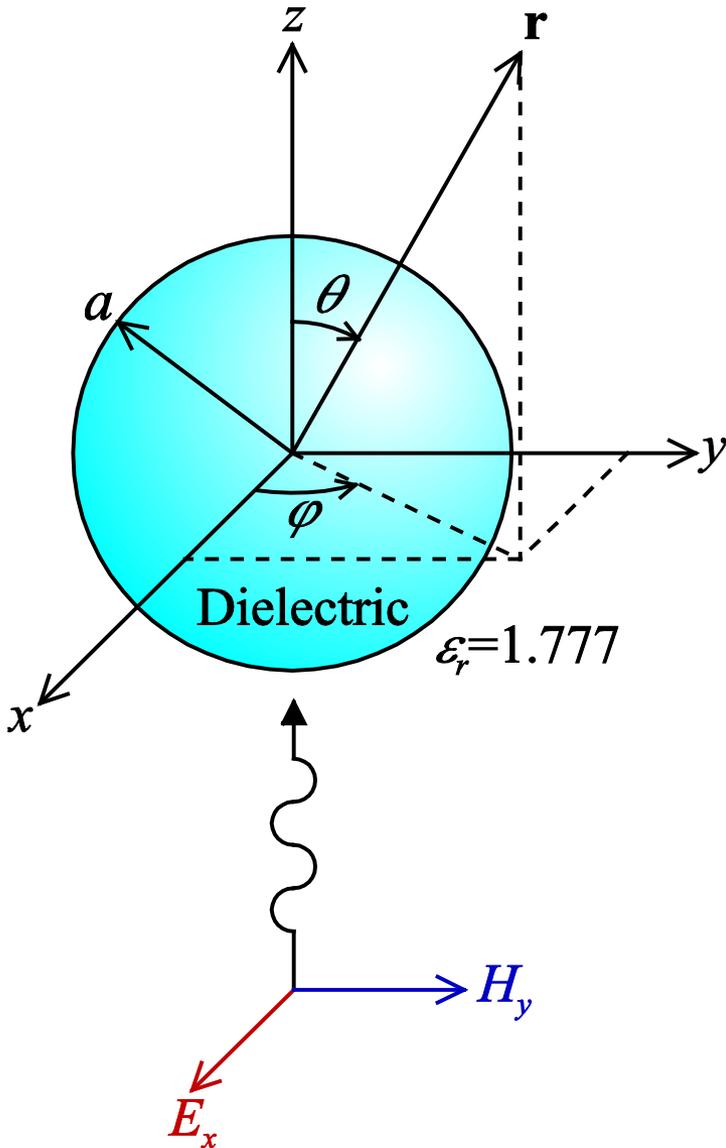


# COMSOLによる誘電体球による平面波散乱の解析

## COMSOL 5.3

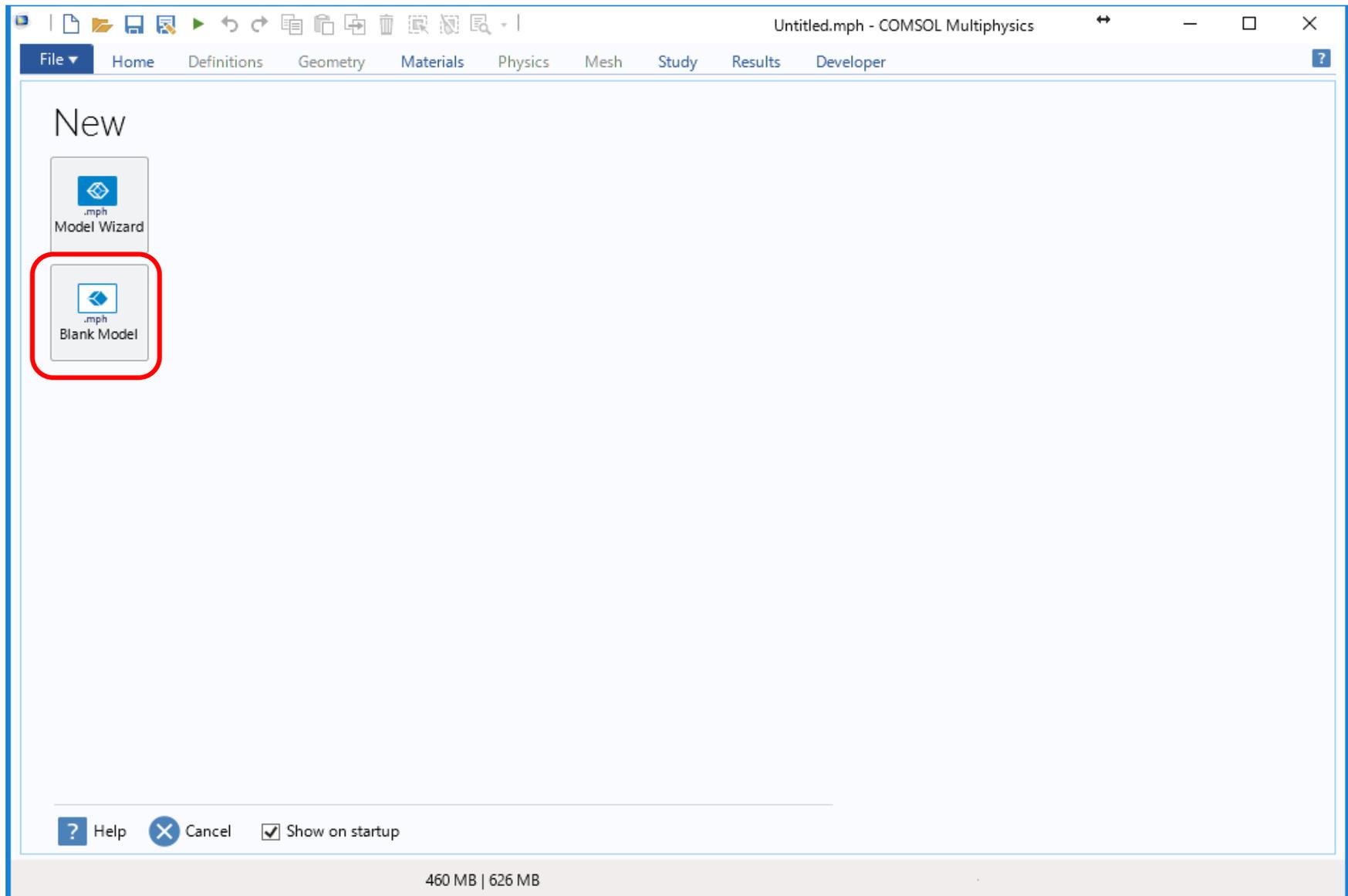


平野 拓一

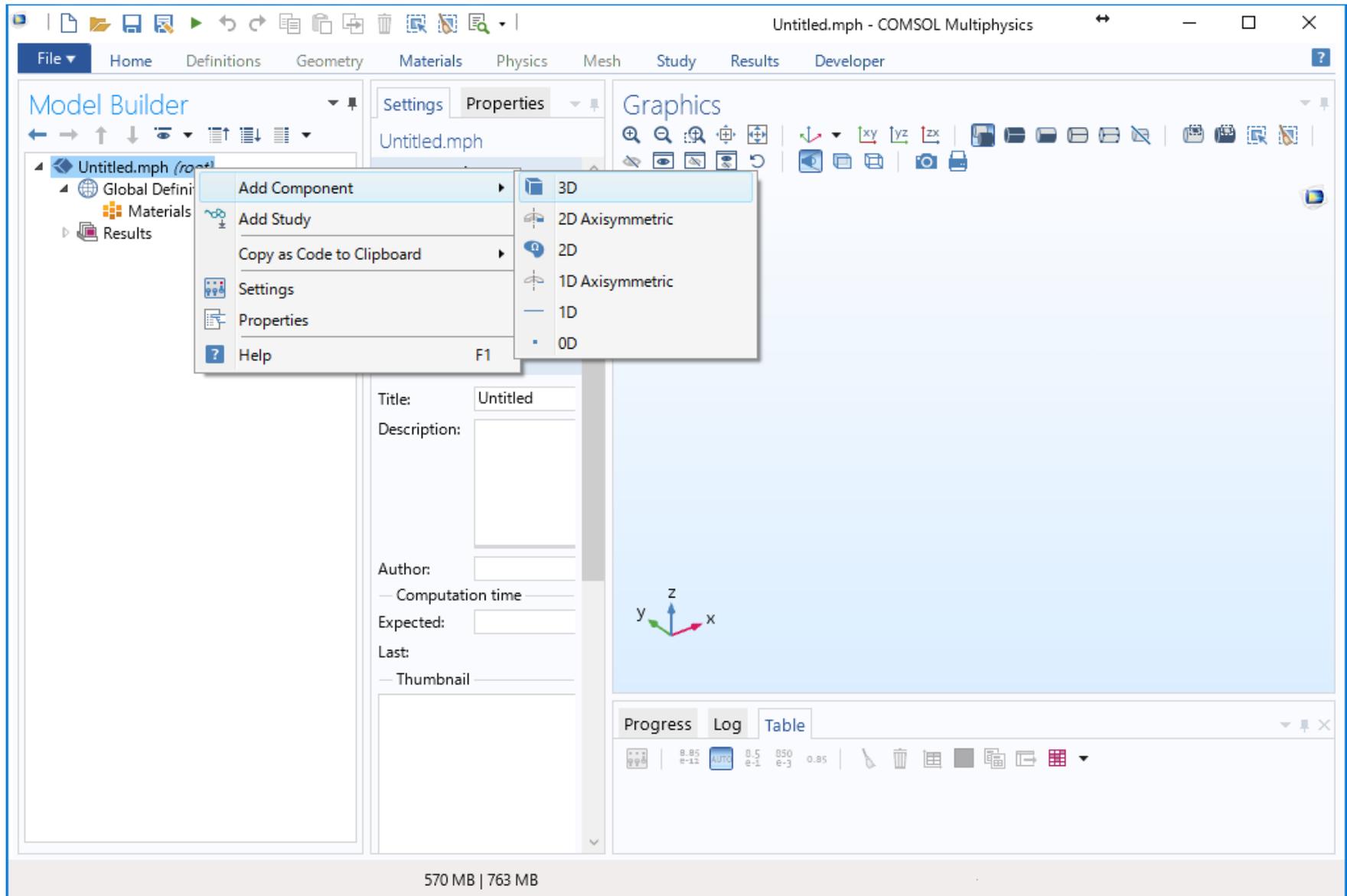


# COMSOLを起動

No. 3



# 3Dモデルを追加



# フィジックスを追加

The screenshot displays the COMSOL Multiphysics software interface. The main window is titled "Untitled.mph - COMSOL Multiphysics". The top menu bar includes "File", "Home", "Definitions", "Geometry", "Materials", "Physics", "Mesh", "Study", "Results", and "Developer".

The left sidebar shows the "Model Builder" tree structure:

- Untitled.mph (root)
  - Global Definitions
  - Materials
  - Component 1 (comp1)
    - Definitions
    - Geometry 1
      - Form Union (fin)
      - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
    - Mesh 1
    - Results

The central "Properties" pane shows the settings for the selected "Electromagnetic Waves, Frequency Domain" physics interface:

- Label: Electromagne
- Name: emw
- Domain Selection: All domain
- Selection: All domain
- Active:
- Equation
- Settings
  - Formulation: Full field
- Port Sweep Settings
  - Activate port sweep:
- Analysis Methodolog
  - Methodology options: Fast
- Physics-Controlled M

The right sidebar shows the "Add Physics" dialog box, which is currently empty. It includes a search bar and a list of physics interfaces under the "Recently Used" section:

- Electromagnetic Waves, Frequency Doma
- Transmission Line (tl)
- AC/DC
- Acoustics
- Chemical Species Transport
- Fluid Flow
- Heat Transfer
- Radio Frequency
- Electromagnetic Waves, Frequency Doma
- Electromagnetic Waves, Time Explicit (ew
- Electromagnetic Waves, Transient (temw)
- Transmission Line (tl)
- Structural Mechanics
- Mathematics

The bottom status bar shows "628 MB | 776 MB".

# スタディを追加

The screenshot displays the COMSOL Multiphysics software interface. The main window is titled "Untitled.mph - COMSOL Multiphysics". The interface is divided into several panes:

- Model Builder:** Shows the project hierarchy. Under "Study 1", "Step 1: Frequency Domain" is selected.
- Settings Properties:** Shows the configuration for the "Frequency Domain" study. The "Label" is "Frequency Domain". Under "Study Settings", "Frequency unit:" and "Frequencies:" are visible. Under "Physics and Variables Selection", "Modify physics tree and variables" is unchecked. The "Physics interface" is set to "Electromagnetic Waves, Frequency Domain".
- Graphics:** A 3D coordinate system (x, y, z) is shown.
- Add Study:** A dialog box is open, showing a list of "Preset Studies":
  - Boundary Mode Analysis
  - Eigenfrequency
  - Frequency Domain (selected)
  - Frequency-Domain Modal
  - Custom Studies
  - Empty Study
 Below the list, the "Physics interfaces in study" section shows "Electromagnetic Waves, Frequency Domain" is selected and checked. The "Solve" button is visible.
- Progress Log Table:** A table is visible at the bottom, showing progress information. The table has columns for "Progress", "Log", and "Table". The "Table" column shows values: 8.85, 0.5, 0.50, 0.85. The "Log" column shows values: 8.12, 0.1, 0.3.

At the bottom of the window, the memory usage is displayed as "647 MB | 814 MB".

# 変数を定義

The screenshot displays the COMSOL Multiphysics software interface for a model named "dielectric\_sphere.mph". The interface is divided into several main sections:

- Model Builder:** Shows the hierarchical structure of the model, including Global Definitions, Materials, Component 1 (comp1), Geometry 1, Electromagnetic Waves, Frequency Domain, and Study 1.
- Settings / Properties:** The "Parameters" tab is active, showing a table of defined parameters.
- Graphics:** A 3D coordinate system (x, y, z) is visible, representing the geometry of the sphere.
- Progress / Log / Table:** A table at the bottom right shows the current values of the parameters.

The "Parameters" table in the Settings pane is as follows:

Name	Expression	Value	D
a	1 [m]	1 m	
r_abc	a+1	2 m	
w_pml	0.5	0.5	

The "Table" pane at the bottom right displays the following data:

Parameter	Value
a	0.5
r_abc	0.50
w_pml	0.85

At the bottom of the window, the memory usage is indicated as 716 MB | 836 MB.

# 誘電体球を描く

dielectric\_sphere.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Model Builder

- dielectric\_sphere.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Component 1 (comp1)
    - Definitions
    - Geometry 1
      - Sphere 1 (sph1)
      - Form Union (fin)
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
    - Mesh 1
    - Study 1
      - Step 1: Frequency Domain
    - Results

Settings Properties

Sphere

Build Selected Build All Objects

Label: Sphere 1

Object Type

Type: Solid

Size

Radius: a m

Position

x: 0 m

y: 0 m

z: 0 m

Axis

Axis type: z-axis

Rotation Angle

Rotation: 0 deg

Coordinate System

Work plane: xy-plane

Layers

Graphics

Progress Log Table

726 MB | 866 MB

# 空気とPMLを描く

COMSOLでは球は玉ねぎのように多層にできる。  
PMLを設定するときは外側の層をPMLに設定する。

Layer name	Thickness (m)
Layer 1	w_pml
Layer 2	

# 材料(真空)の設定

The screenshot shows the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The "Materials" tab is active in the Settings/Properties panel, showing the material "Vacuum" selected. The "Geometric Entity Selection" section indicates that "All domains" are selected. The "Material Contents" table is visible at the bottom of the settings panel.

Property	Name	Value
<input checked="" type="checkbox"/> Relative permittivity	epsilon <sub>nr</sub>	1
<input checked="" type="checkbox"/> Relative permeability	mu <sub>r</sub>	1
<input checked="" type="checkbox"/> Electrical conductivity	sigma	0

The Graphics window on the right shows a 3D visualization of a sphere with a blue mesh, centered at the origin of a Cartesian coordinate system (x, y, z). The axes are labeled with values from -2 to 2 meters.

777 MB | 906 MB

# 材料(誘電体)の設定

The screenshot displays the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The "Materials" tab is active, showing the "Properties" section for a material labeled "Dielectric".

**Material Properties List:**

- Density
- Diffusion Coefficient
- Dynamic Viscosity
- Electrical Conductivity (highlighted)
- Electron Mobility
- Extinction Coefficient
- Frequency Factor
- Heat Capacity at Constant Pressure
- Isotropic Structural Loss Factor
- Mass Flux
- Mean Molar Mass
- Permeability

**Geometric Entity Selection:**

- Geometric entity level: Domain
- Selection: Manual
- Active: [ON]

**Model Builder (Left Panel):**

- ectric\_sphere.mph (root)
- Global Definitions
- Parameters
- Materials
- Component 1 (comp1)
- Definitions
- Geometry 1
  - Sphere 1 (sph1)
  - Sphere 2 (sph2)
  - Form Union (fin)
- Materials
  - Vacuum (mat1) - Basic
  - Dielectric (mat2) - Basic
- Electromagnetic Waves, Frequency Domain
  - Wave Equation, Electric 1
  - Perfect Electric Conductor 1
  - Initial Values 1
- Mesh 1
- Study 1
  - Step 1: Frequency Domain
- Results

**Graphics (Right Panel):**

A 3D visualization of a sphere centered at the origin of a Cartesian coordinate system (x, y, z). The axes range from -2 to 2 meters. The sphere is rendered with a semi-transparent gray material, showing its internal structure and the coordinate axes.

**Progress (Bottom Panel):**

The progress bar shows the simulation is at 0.5 (50%) of the total time. The total time is 0.85 seconds. The current time step is 0.5 seconds. The time step size is 0.50 seconds. The time step size is 0.85 seconds. The time step size is 0.85 seconds.

# 材料(誘電体)の設定

The screenshot shows the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The Model Builder tree on the left shows the hierarchy: Component 1 (comp1) > Materials > Dielectric (mat2) > Basic. The Properties panel in the center shows the "Basic" property group for the selected material. The "Output Properties and Model Inputs" section is expanded, showing a table of properties.

Property	Variable	Expression
Relative permittivity	epsilon...	1.777
Relative permeability	mur ; m...	1
Electrical conductiv...	sigma ;...	0

The Graphics window on the right shows a 3D visualization of a sphere with a radius of 2 meters, centered at the origin of a Cartesian coordinate system (x, y, z). The axes are labeled with values -2, 0, and 2 meters.

755 MB | 870 MB

# 材料(誘電体)の設定

The screenshot displays the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The software is running in the "Materials" tab. The "Model Builder" on the left shows a hierarchy of components: Component 1 (comp1) contains Geometry 1 with two spheres (sph1 and sph2) and a Form Union (fin). Under Materials, there are Vacuum (mat1) and Dielectric (mat2), both with Basic properties. The "Settings" pane for the selected "Dielectric" material shows the "Geometric Entity Selection" set to "Domain" and "Manual". The "Material Properties" list includes Basic Properties, Acoustics, Electrochemistry, Electromagnetic Models, Equilibrium Discharge, External Material Parameters, Gas Models, Magnetostrictive Models, Piezoelectric Models, Piezoresistive Models, and Semiconductors. The "Graphics" window on the right shows a 3D visualization of a sphere with a red dielectric core and a grey vacuum shell, overlaid on a coordinate system with axes x, y, and z. The "Progress" window at the bottom shows the simulation progress with a table view.

dielectric\_sphere.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Model Builder

ectric\_sphere.mph (root)

Global Definitions

Parameters

Materials

Component 1 (comp1)

Definitions

Geometry 1

Sphere 1 (sph1)

Sphere 2 (sph2)

Form Union (fin)

Materials

Vacuum (mat1)

Basic

Dielectric (mat2)

Basic

Electromagnetic Waves, Frequency Domain

Wave Equation, Electric 1

Perfect Electric Conductor 1

Initial Values 1

Mesh 1

Study 1

Step 1: Frequency Domain

Results

Settings Properties

Material

Label: Dielectric

Geometric Entity Selection

Geometric entity level: Domain

Selection: Manual

ON 6

Active

Override

Material Properties

- Basic Properties
- Acoustics
- Electrochemistry
- Electromagnetic Models
- Equilibrium Discharge
- External Material Parameters
- Gas Models
- Magnetostrictive Models
- Piezoelectric Models
- Piezoresistive Models
- Semiconductors

Graphics

Progress Log Table

762 MB | 885 MB

# 励振平面波の設定

The screenshot displays the COMSOL Multiphysics interface for a simulation titled "dielectric\_sphere.mph". The software is running in the "Frequency Domain" mode for "Electromagnetic Waves".

**Model Builder (Left Panel):**

- ectric\_sphere.mph (root)
- Global Definitions
- Parameters
- Materials
- Component 1 (comp1)
- Definitions
- Geometry 1
  - Sphere 1 (sph1)
  - Sphere 2 (sph2)
  - Form Union (fin)
- Materials
  - Vacuum (mat1) - Basic
  - Dielectric (mat2) - Basic
- Electromagnetic Waves, Frequency Domain
  - Wave Equation, Electric 1
  - Perfect Electric Conductor 1
  - Initial Values 1
- Mesh 1
- Study 1
  - Step 1: Frequency Domain
- Results

**Settings Panel (Middle):**

Label: Electromagnetic Waves, Frequency Domain  
Name: emw

Domain Selection: All domains

Active: 1, 2, 3, 4, 5, 6

Equation: Scattered field

Settings: Formulation: Scattered field

Background wave type: User defined

Background electric field:

$\exp(-j*\text{emw.k0}*z)$	x	V/m
0	y	
0	z	

Port Sweep Settings

**Graphics Window (Right):**

The Graphics window shows a 3D visualization of a sphere centered at the origin of a Cartesian coordinate system (x, y, z). The axes range from -2 to 2 meters. The sphere is rendered in a blue color. The coordinate system is labeled with x, y, and z axes, and the origin is marked as 0 m.

**Progress Bar (Bottom):**

Progress: 8.85 e-12, 0.5 e-1, 0.50 e-3, 0.95

774 MB | 900 MB

# PMLの設定

The screenshot displays the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The "Model Builder" tree on the left shows the hierarchy: dielectric\_sphere.mph (root) > Global Definitions > Parameters > Materials > Component 1 (comp1) > Definitions > Boundary System 1 (sys1) > Perfectly Matched Layer 1 (pml1). The "Settings" pane for "Perfectly Matched Layer" is active, showing the following configuration:

- Label: Perfectly Matched Layer 1
- Name: pml1
- Domain Selection: Manual
- Selection: 1, 2, 3, 4, 7, 8
- Active: ON
- Override: (empty)
- Geometry: Spherical
- Type: Spherical
- Center coordinate: Xm (m) = 0, Ym (m) = 0, Zm (m) = 0
- Scaling: Coordinate stretching type: Polynomial
- Typical wavelength from: (empty)

The "Graphics" window on the right shows a 3D visualization of a blue sphere centered at the origin of a coordinate system with axes x, y, and z. The axes are labeled with values -2, 0, and 2, with units in meters (m). The sphere is surrounded by a grid of lines representing the PML domain.

At the bottom of the interface, the status bar indicates "778 MB | 901 MB".

# 遠方界領域の設定

The screenshot displays the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The software is running in the "Study" tab, and the "Far-Field Domain" settings are currently active.

**Model Builder:** The left-hand pane shows the model's structure. Under "Component 1 (comp1)", the "Far-Field Domain 1" is selected. The model includes two spheres, "Sphere 1 (sph1)" and "Sphere 2 (sph2)", which are combined into a "Form Union (fin)". The physics interface includes "Electromagnetic Waves, Frequency Domain" with "Wave Equation, Electric 1" and "Perfect Electric Conductor 1" applied to the spheres.

**Settings - Far-Field Domain:** The central pane shows the configuration for "Far-Field Domain 1". The "Domain Selection" is set to "Manual", and domain "5" is selected and active. The "Override and Contribution" section is currently empty.

**Graphics:** The right-hand pane shows a 3D visualization of the model. A green dielectric sphere is centered at the origin of a 3D coordinate system (x, y, z). The axes range from -2 to 2 meters. The sphere is surrounded by a grid representing the far-field domain.

**Progress:** The bottom status bar shows the progress of the simulation, with values such as 8.85e-12, 0.5e-1, and 0.85.

789 MB | 921 MB

# スタディを追加 & 解析

dielectric\_sphere.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Model Builder

- dielectric\_sphere.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Component 1 (comp1)
    - Definitions
      - Boundary System 1 (sys1)
      - Perfectly Matched Layer 1 (pr)
      - View 1
    - Geometry 1
      - Sphere 1 (sph1)
      - Sphere 2 (sph2)
      - Form Union (fin)
    - Materials
      - Vacuum (mat1)
        - Basic
      - Dielectric (mat2)
        - Basic
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Far-Field Domain 1
    - Mesh 1
    - Study 1
      - Step 1: Frequency Domain
      - Results

Settings Properties

Frequency Domain

Compute

Label: Fre Compute (F8)

Study Settings

Frequency unit: MHz

Frequencies: 300 MHz

Load parameter values: Browse... Re...

Reuse solution from previous step: Auto

Results While Solving

Physics and Variables Selection

Modify physics tree and variables for study step

Physics interface	Solve for	Discretiza
Electromagnetic Waves, F...	<input checked="" type="checkbox"/>	Physics

Values of Dependent Variables

Mesh Selection

Adaptation and Error Estimates

Study Extensions

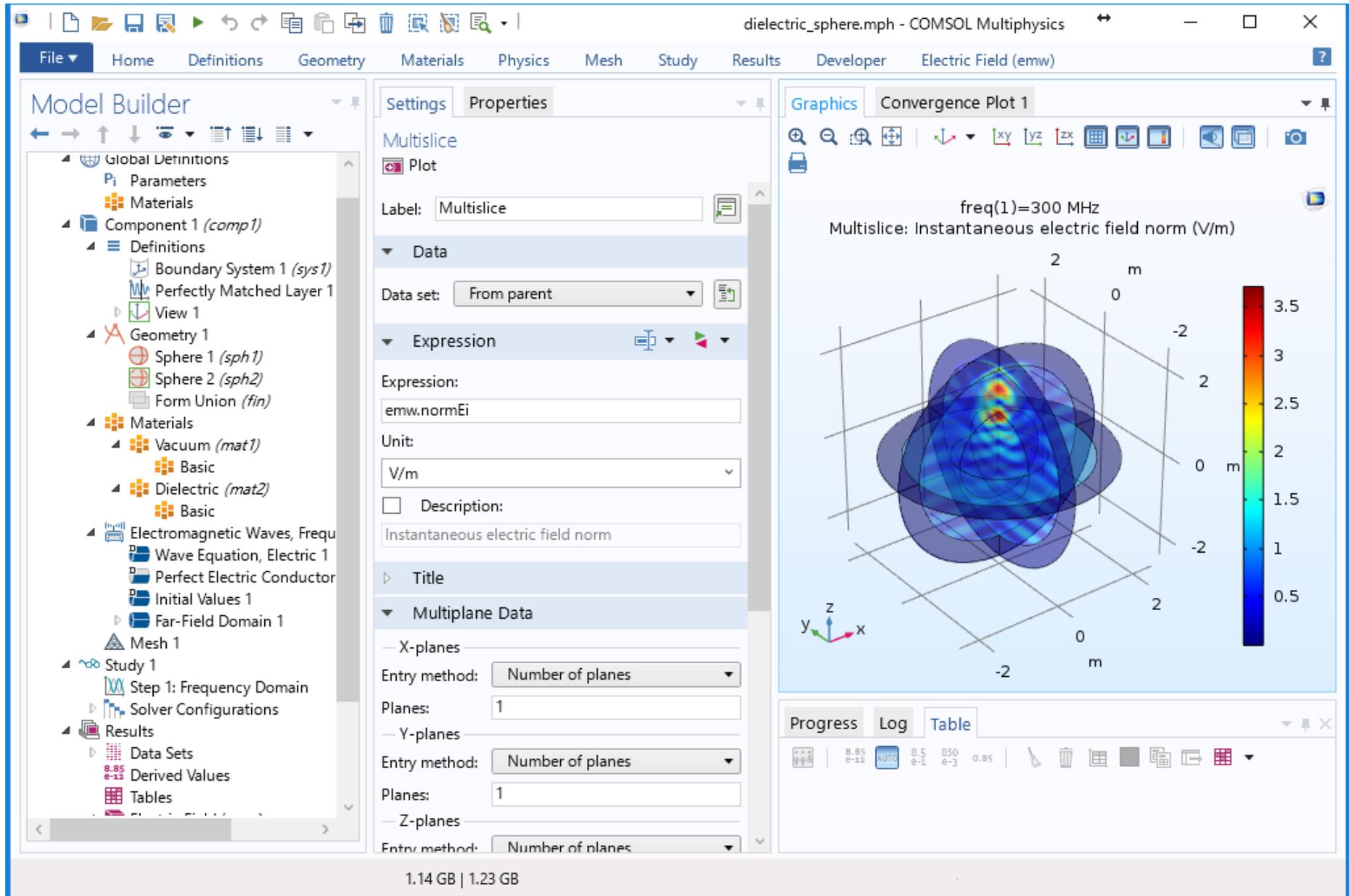
Graphics

波長は1m

Progress Log Table

747 MB | 876 MB

# 電界強度分布(瞬時値)



# 電界強度分布(瞬時値の時間アニメーション) No. 19

dielectric\_sphere.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer Electric Field (emw)

Plot Electric Field (emw) 3D Plot Group 2D Plot Group 1D Plot Group Polar Plot Group Smith Plot Group

Definitions

Cut Plane Cut Line 3D More Data Sets Selection Remesh Deformed Configuration

8.85 e-12 Derived Values Table

Data Image Animation Player File Report

Label: Electric Field (emw)

Data

Data set: Study 1/Sol

Parameter value (freq (MHz)): 300

Title

Plot Settings

View: Automatic

Show hidden entities

Propagate hiding to lower dimensions

Plot data set edges

Color: Black

Frame: Spatial (x, y, z)

Color Legend

Show legends

Show maximum and minimum values

Show units

Position: Right

Text color: Black

Multislice: Instantaneous electric f

3.5 3 2.5 2 1.5 1 0.5

2 0 -2 2 0 -2 2 0 -2

z y x

Progress Log Directivity

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

1.09 GB | 1.16 GB

# 電界強度分布(瞬時値の時間アニメーション) No. 20

dielectric\_sphere.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Model Builder

- Sphere 1 (sph1)
- Sphere 2 (sph2)
- Form Union (fin)
- Materials
  - Vacuum (mat1)
    - Basic
  - Dielectric (mat2)
    - Basic
- Electromagnetic Waves, Frequency Domain
  - Wave Equation, Electric 1
  - Perfect Electric Conductor
  - Initial Values 1
  - Far-Field Domain 1
- Mesh 1
- Study 1
  - Step 1: Frequency Domain
  - Solver Configurations
  - Results
    - Data Sets
    - Views
    - Derived Values
    - Tables
    - Electric Field (emw)
      - Multislice
      - 2D Far Field (emw)
      - 3D Far Field (emw)
      - 1D Plot Group
    - Export
      - Animation 1
    - Reports

Settings Properties

Animation

Show Frame

Label: Animation 1

Scene

Subject: Electric Field (emw)

Target

Target: Player

Animation Editing

Sequence type: Dynamic data exte

Cycle type: Full harmonic

Frames

Number of frames: 16

Frame number: 1

Phase shift: 0

Playing

Display each frame for: 0.1 s

Repeat

Advanced

Graphics Convergence Plot 1

freq(1)=300 MHz

Multislice: Instantaneous electric field norm (V/m)

4

3.5

3

2.5

2

1.5

1

0.5

2

0

-2

2

0

-2

2

0

-2

m

m

m

z

y

x

Progress Log Directivity

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

1.25 GB | 1.37 GB

# 遠方界(3D RCS)の出力

dielectric\_sphere.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer 3D Far Field (emw)

Model Builder

- View 1
- Geometry 1
  - Sphere 1 (sph1)
  - Sphere 2 (sph2)
  - Form Union (fin)
- Materials
  - Vacuum (mat1)
    - Basic
  - Dielectric (mat2)
    - Basic
- Electromagnetic Waves, Frequency Domain
  - Wave Equation, Electric 1
  - Perfect Electric Conductor
  - Initial Values 1
  - Far-Field Domain 1
- Mesh 1
- Study 1
  - Step 1: Frequency Domain
  - Solver Configurations
  - Results
    - Data Sets
    - Views
    - Derived Values
    - Tables
    - Electric Field (emw)
      - Multislice
    - 2D Far Field (emw)
    - 3D Far Field (emw)
      - Far Field 1
    - 1D Plot Group

Settings Properties

Far Field

Plot

Label: Far Field 1

Data

Data set: From parent

Expression

Expression: emw.bRCS3D

Unit: m<sup>2</sup>

Description: Bistatic radar cross section

Threshold:  0 m<sup>2</sup>

Use as color expression

Title

Range

Evaluation

Angles

Number of elevation angles: 100

Number of azimuth angles: 50

Restriction: None

Graphics Convergence Plot 1

freq(1)=300 MHz

Far Field: Bistatic radar cross section (m<sup>2</sup>)

50

-50

400

200

0

50

-50

z

y

x

▲ 499

450

400

350

300

250

200

150

100

50

▼ 0.08

Progress Log Directivity

θ (deg)	φ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

1.11 GB | 1.18 GB

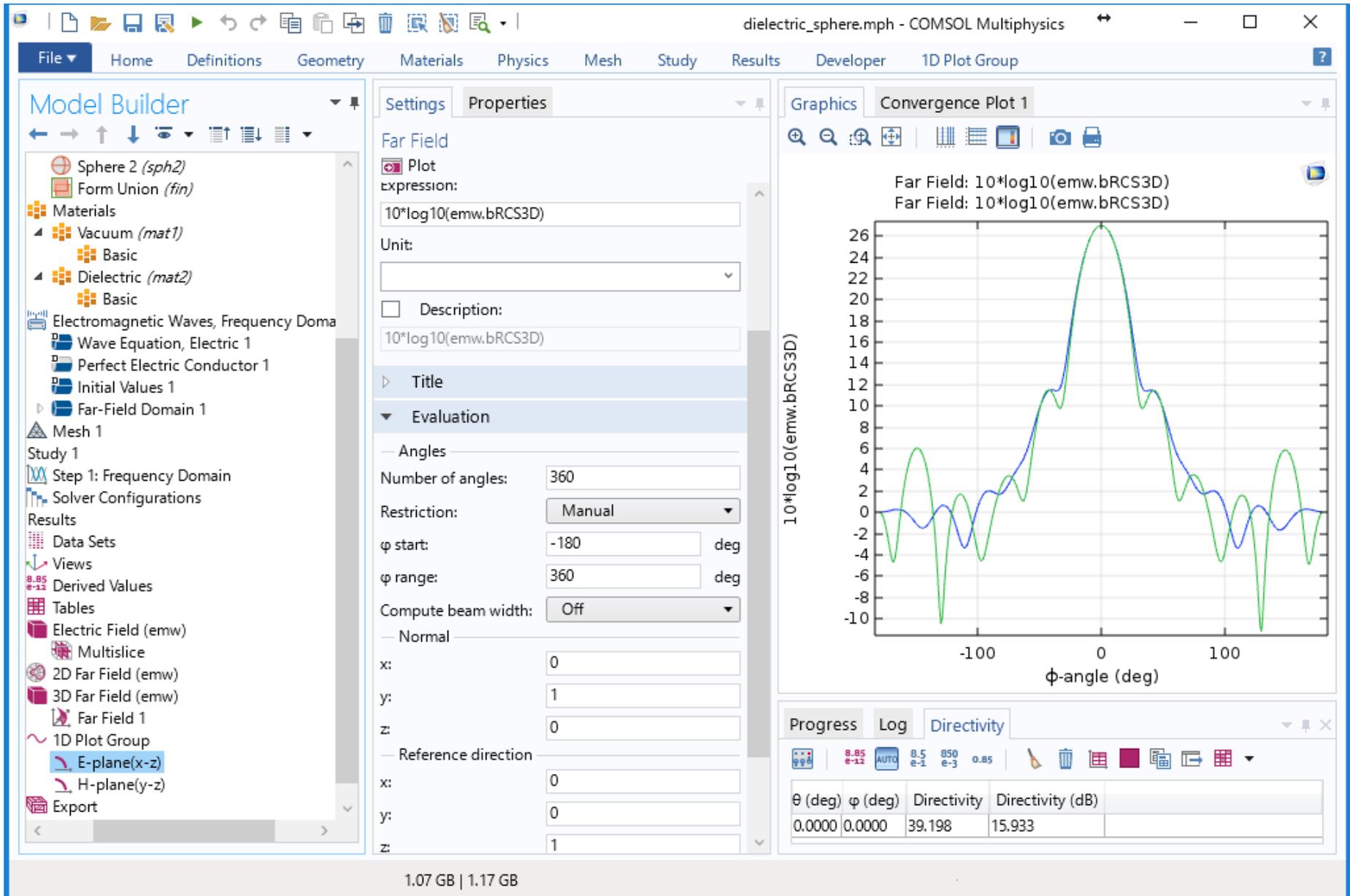
# 遠方界(1D RCS)の出力

The screenshot displays the COMSOL Multiphysics interface for a model named 'dielectric\_sphere.mph'. The 'Model Builder' tree on the left shows the hierarchy of the model, including 'Study 1' and 'Results'. A context menu is open over the 'Results' node, with 'More Plots' selected, showing options like 'Nyquist' and 'Far Field'. The 'Graphics' window on the right shows a 'Convergence Plot 1' with a grid. The 'Progress' window at the bottom right shows a 'Directivity' table with the following data:

$\theta$ (deg)	$\varphi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

1.11 GB | 1.17 GB

# 遠方界(1D RCS)の出力



# 1D プロットをCSVファイルにエクスポート

The screenshot displays the COMSOL Multiphysics interface for a simulation titled "dielectric\_sphere.mph". The left sidebar shows the "Model Builder" tree with a context menu open over the "1D" plot type. The menu options include Data, Plot, Mesh, Table, 3D Image, 2D Image, 1D Image, Animation, Export All, Copy as Code to Clipboard, Settings, Properties, and Help (F1). The main window shows a "Convergence Plot 1" with the following title and axes:

Far Field:  $10 \cdot \log_{10}(\text{emw.bRCS3D})$   
Far Field:  $10 \cdot \log_{10}(\text{emw.bRCS3D})$

The y-axis is labeled  $10 \cdot \log_{10}(\text{emw.bRCS3D})$  and ranges from -10 to 26. The x-axis is labeled  $\phi$ -angle (deg) and ranges from -100 to 100. The plot shows a radiation pattern with a main lobe at  $\phi = 0$  and side lobes.

At the bottom, the "Progress" and "Log" tabs are visible, along with a "Directivity" table:

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

System memory usage is shown at the bottom as 1.26 GB | 1.38 GB.

# 1D プロットをCSVファイルにエクスポート

The screenshot displays the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The left-hand side shows the Model Builder tree with the following structure:

- Sphere 2 (*sph2*)
- Form Union (*fin*)
- Materials
  - Vacuum (*mat1*)
  - Basic
  - Dielectric (*mat2*)
  - Basic
- Electromagnetic Waves, Frequency Domain
  - Wave Equation, Electric 1
  - Perfect Electric Conductor
  - Initial Values 1
  - Far-Field Domain 1
  - Mesh 1
- Study 1
  - Step 1: Frequency Domain
  - Solver Configurations
- Results
  - Data Sets
  - Views
  - Derived Values
  - Tables
  - Electric Field (*emw*)
  - 2D Far Field (*emw*)
  - 3D Far Field (*emw*)
  - 1D Plot Group
    - E-plane(x-z)
    - H-plane(y-z)
  - Export
    - Animation 1
    - Plot 1

The central Properties window for "Plot 1" is open, showing the following settings:

- Plot group: 1D Plot Group
- Plot: E-plane(x-z)
- Output
  - File type: Text
  - Filename: e\_plane.csv
  - Always ask for filename:
  - Data format: Spreadsheet
- Advanced: (collapsed)

The right-hand side of the interface shows a "Convergence Plot 1" window with the title "Far Field: 10\*log10(emw.bRCS3D)". The plot displays a blue curve representing the directivity pattern, with a peak at 0 degrees. The y-axis is labeled "10\*log10(emw.bRCS3D)" and ranges from -2 to 26. The x-axis is labeled "φ-angle (deg)" and ranges from -100 to 100.

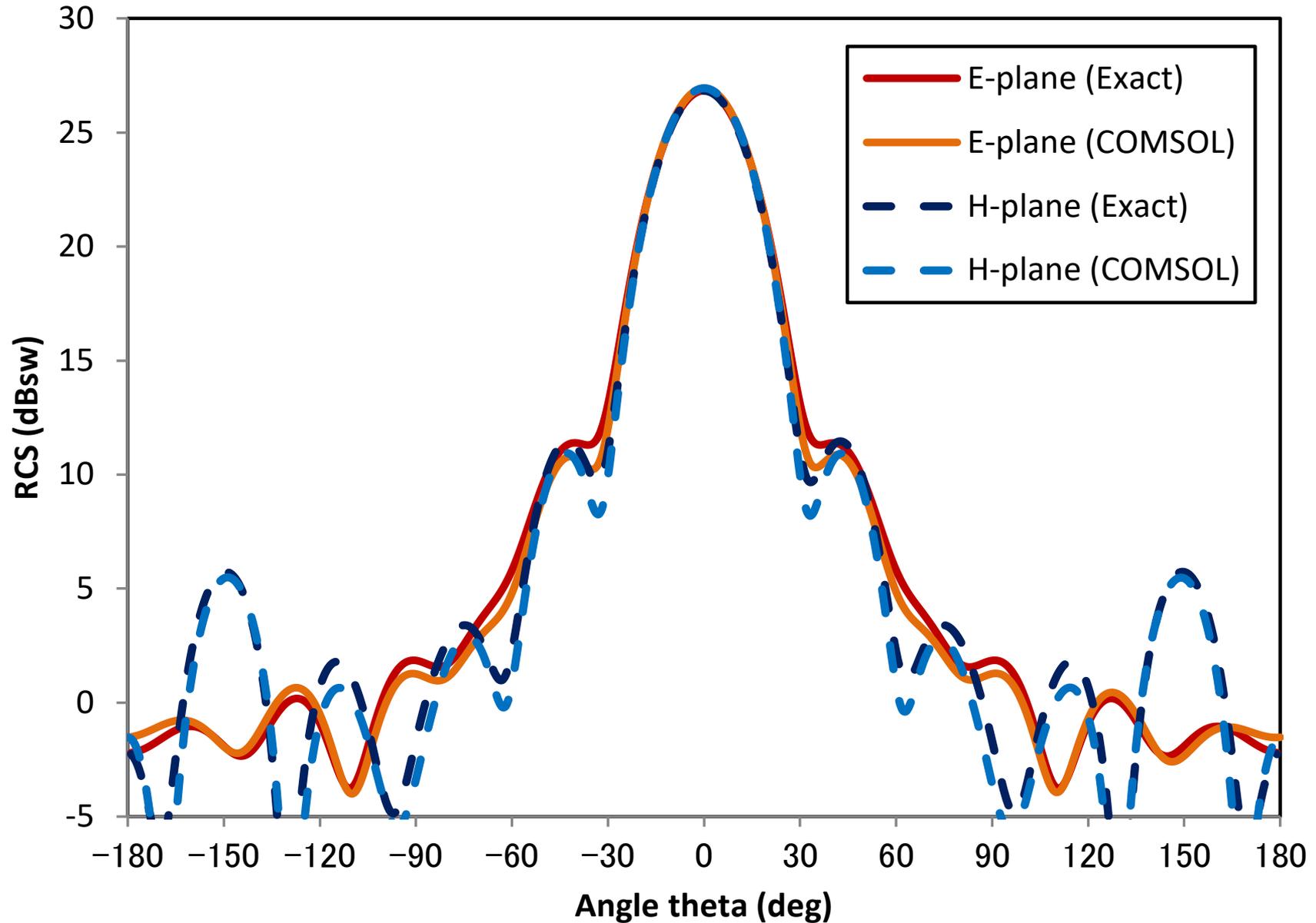
At the bottom of the interface, the Progress window is visible, showing a table of data for the current simulation step:

θ (deg)	φ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

The status bar at the bottom indicates a memory usage of 1.24 GB | 1.35 GB.

## 厳密解との比較

ABCはPMCでないと上手くいかない。



# 【発展】メッシュ制御

The screenshot displays the COMSOL Multiphysics interface for a model named "dielectric\_sphere.mph". The "Mesh" tab is active, showing the "Mesh 1" settings. The "Element size" dropdown menu is open, listing options from "Extremely fine" to "Extremely coarse", with "Normal" selected. The "Graphics" window shows a 3D view of a sphere with a mesh, overlaid on a coordinate system with axes labeled x, y, and z. The axes range from -2 to 2 meters. The "Progress" window at the bottom shows a table of results for Directivity.

$\theta$ (deg)	$\varphi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

1.21 GB | 1.3 GB

# 【発展】解析結果を削除してファイルサイズを小さく No.28

The screenshot shows the COMSOL Multiphysics interface for a file named 'dielectric\_sphere.mph'. The 'Mesh' tab is selected in the top ribbon. The left-hand tree view shows the model hierarchy, including 'Geometry 1' containing two spheres ('sph1' and 'sph2') and a 'Form Union' ('fin'). The central 3D view displays the two overlapping spheres with a mesh applied. The 'Clear All Meshes' button in the top right corner is highlighted with a red box. Below the 3D view, a 'Progress' window is open, showing a table of results.

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

At the bottom of the interface, the file size is indicated as 1.21 GB | 1.3 GB.

# 【発展】解析結果を削除してファイルサイズを小さく<sup>No.29</sup>

The screenshot shows the COMSOL Multiphysics software interface for a model named 'dielectric\_sphere.mph'. The 'Study' tab is active, and the 'Clear All Solutions' button is highlighted with a red rectangle. The interface includes a toolbar with various study and analysis tools, a left-hand tree view showing the model hierarchy, a central property panel for 'Geometry 1', and a 3D visualization of the model. The 3D view shows a sphere with a complex mesh structure. The status bar at the bottom indicates a file size of 1.05 GB | 1.14 GB.

COMSOL Multiphysics - dielectric\_sphere.mph

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Compute Study 1 Add Study Get Initial Value Show Default Solver Study Steps Parametric Sweep Function Sweep Material Sweep Combine Solutions Study Reference Create Solution Copy Statistics Clear Solutions Clear All Solutions

Parameters  
Materials  
Component 1 (comp1)  
Definitions  
Boundary System 1 (sys1)  
Perfectly Matched Layer 1 (pml1)  
View 1  
Geometry 1  
Sphere 1 (sph1)  
Sphere 2 (sph2)  
Form Union (fin)  
Materials  
Vacuum (mat1)  
Basic  
Dielectric (mat2)  
Basic  
Electromagnetic Waves, Frequency Domain  
Wave Equation, Electric 1  
Perfect Electric Conductor 1  
Initial Values 1  
Far-Field Domain 1  
Mesh 1  
Study 1  
Results

Label: Geometry 1

Units  
 Scale values when changing units  
Length unit: m  
Angular unit: Degrees  
Advanced  
Default repair tolerance: Automatic  
 Automatic rebuild

Progress Log Directivity

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
0.0000	0.0000	39.198	15.933

1.05 GB | 1.14 GB