

Non-equilibrium Transitions in Sub/Second Harmonic Generation: Quantum Theory

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Import libraries and define style parameters

```
In[662]:= ClearAll["Global`*"] (* Clear variables and memory *)
```

Import libraries:

```
In[663]:= Needs["MaTeX`"] ; (* To use latex *)
Needs["SciDraw`"] ; (* To draw plots *)
Needs["CustomTicks`"] ; (* To custormize the plots *)
```

Define colors for plots:

```
In[1309]:= Color1 = RGBColor[0.161, 0.419, 0.505];
Color2 = RGBColor[0.90, 0.631, 0.243];
Color3 = RGBColor[0.784, 0.325, 0.235];
```

Define additional parameters:

```
In[770]:= SetOptions[LogTicks,
  MajorTickLength -> {0.03, 0},
  MinorTickLength -> {0.013, 0}]; (* Define tick sizes in lof plots *)
SetOptions[LinTicks,
  MajorTickLength -> {0.025, 0},
  MinorTickLength -> {0.015, 0}]; (* Define tick sizes in line plots *)
```

Numerical Calculation

Define functions:

```
In[669]:= R[w_] := (α1^2 + γ1 - ω^2)^2 - ω^2 * (γ1 + 1)^2 - α2^2 * (1 - ω^2);
J[w_] := 2 * ω * (α2^2 - (γ1 + 1) * (α1^2 + γ1 - ω^2));
S12[w_] := (α2^2 * (ω^2 + 1) * (α1^2 + γ1 * (ω^2 + 1))) / (π * (R[w]^2 + J[w]^2));
S34[w_] := (α2^2 * α1^2 * (α1^2 + γ1 * (ω^2 + 1))) / (π * (R[w]^2 + J[w]^2));
```

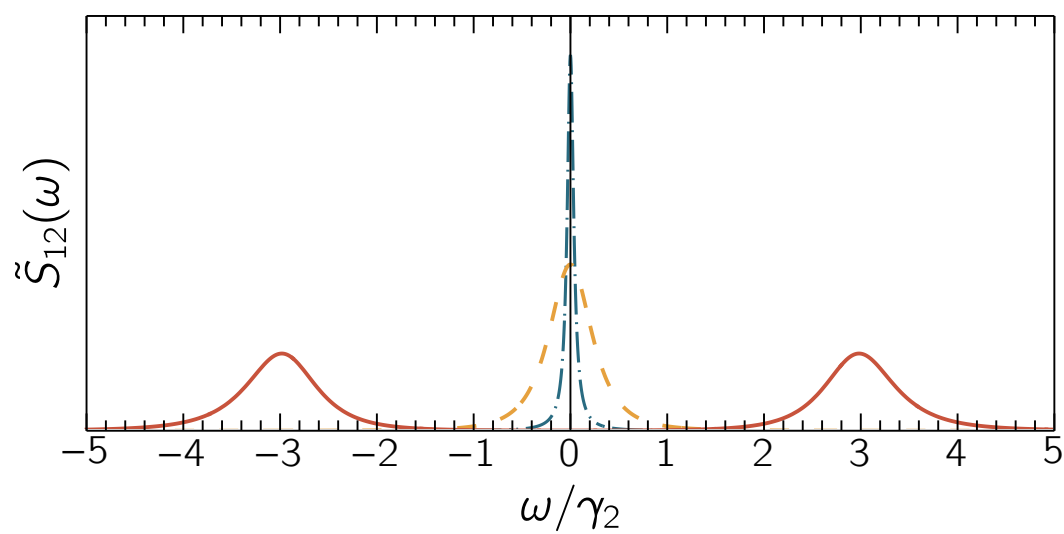
In[1654]:=

```

 $\alpha_1 = 0;$ 
 $\alpha_2 = 0.2;$ 
 $\gamma_1 = 0.5;$ 
P2 = Plot[S12[ $\omega$ ] / 2, { $\omega$ , -5, 5}, PlotRange → All, PlotStyle → {Color2, Dashing[Large, Small], Thick}];
 $\alpha_1 = 0;$ 
 $\alpha_2 = 0.46;$ 
 $\gamma_1 = 0.5;$ 
P1 = Plot[S12[ $\omega$ ] / 140, { $\omega$ , -5, 5}, PlotRange → All, PlotStyle → {Color1, Dashing[{0, Small, Large, Small}]}];
 $\alpha_2 = 0.5;$ 
 $\gamma_1 = 0.5;$ 
 $\alpha_1 = \text{Sqrt}[2 * (5 - 0.5)];$ 
P3 = Plot[S12[ $\omega$ ], { $\omega$ , -5, 5}, PlotRange → All, PlotStyle → {Color3, Thick}];
F1 = Figure[
  FigurePanel[
    {
      FigGraphics[P1];
      FigGraphics[P2];
      FigGraphics[P3];
      FigRule[Vertical, 0, All];
    },
    XPlotRange → {-5, 5},
    XFrameLabel → textit[MaTeX["\\omega/\\gamma_2", FontSize → 25, "Preamble" → {"\\usepackage{cmbright}"}]],
    YPlotRange → {0, 0.18},
    YFrameLabel → textit[MaTeX["\\tilde{S}_{12}(\\omega)", FontSize → 25, "Preamble" → {"\\usepackage{cmbright}"}]],
    FontSize → 25,
    FontFamily → "CMU Bright",
    YTicks → None,
    XTicks → LinTicks[-5, 5, 1, 5]
  ],
  CanvasSize → {7, 3},
  CanvasMargin → 1.1]

```

Out[1666]=



In[1669]:=

```

F1Legend = Plot[{0, 0, 0}, { $\omega$ , -5, 5},
  PlotStyle → {{Color2, Dashing[Large, Small], Thick}, {Color1, Dashing[{0, Small, Large, Small}]}, {Color3, Thick}},
  PlotLegends → {
    MaTeX["\\kappa\\epsilon_2/\\gamma_2^2 = 0.20", FontSize → 20, "Preamble" → {"\\usepackage{cmbright}"}],
    MaTeX["\\kappa\\epsilon_2/\\gamma_2^2 = 0.46", FontSize → 20, "Preamble" → {"\\usepackage{cmbright}"}],
    MaTeX["\\kappa\\epsilon_2/\\gamma_2^2 = 5.00", FontSize → 20, "Preamble" → {"\\usepackage{cmbright}"}]}];

```

In[1670]:=

```
Export["fig_1_legend.pdf", F1Legend];
```

```

In[1602]:=
Solve[-2 * x^3 + 4 * 0.58 * x^2 - 2 * 0.5^2 * x == 0.3^2, {x}]
Solve[-2 * x^3 + 4 * 0.58 * x^2 - 2 * 0.5^2 * x == 1^2, {x}]
Solve[-2 * x^3 + 4 * 0.58 * x^2 - 2 * 0.5^2 * x == 3.4^2, {x}]

Out[1602]=
{{x -> -0.113897}, {x -> 0.533943}, {x -> 0.739955}}

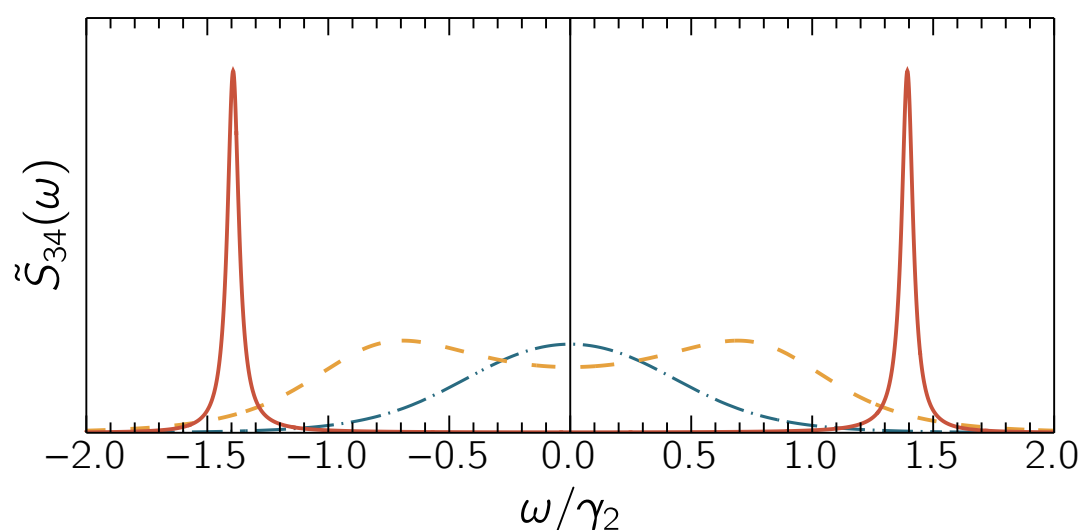
Out[1603]=
{{x -> -0.481042}, {x -> 0.820521 - 0.605108 i}, {x -> 0.820521 + 0.605108 i}}

Out[1604]=
{{x -> -1.44291}, {x -> 1.30146 - 1.52052 i}, {x -> 1.30146 + 1.52052 i}}

In[1617]:=
α2 = -0.113897;
α1 = Sqrt[-2 * α2];
γ1 = 0.5;
P01 = Plot[S34[ω], {ω, -2, 2}, PlotRange -> All, PlotStyle -> {Color1, Dashing[{0, Small, Large, Small}]}];
α2 = -0.481042;
α1 = Sqrt[-2 * α2];
γ1 = 0.5;
P02 = Plot[S34[ω] / 15, {ω, -2, 2}, PlotRange -> All, PlotStyle -> {Color2, Dashing[Large, Small], Thick}];
α2 = -1.44291;
α1 = Sqrt[-2 * α2];
γ1 = 0.5;
P03 = Plot[S34[ω] / 5000, {ω, -2, 2}, PlotRange -> All, PlotStyle -> {Color3, Thick}];

In[1631]:=
F2 = Figure[
  FigurePanel[
    {
      FigGraphics[P01];
      FigGraphics[P02];
      FigGraphics[P03];
      FigRule[Vertical, 0, All];
    },
    XPlotRange -> {-2, 2},
    XFrameLabel -> Text[MaTeX["\\omega/\\gamma_2", FontSize -> 25, "Preamble" -> {"\\usepackage{cmbright}"}]],
    YPlotRange -> {0, 0.012},
    YFrameLabel -> Text[MaTeX["\\tilde{S}_{34}(\\omega)", FontSize -> 25, "Preamble" -> {"\\usepackage{cmbright}"}]],
    FontSize -> 25,
    FontFamily -> "CMU Bright",
    YTicks -> None,
    XTicks -> LinTicks[-5, 5, 0.5, 5]
  ],
  CanvasSize -> {7, 3},
  CanvasMargin -> 1.1]

```



```

In[1636]:=
F2Legend = Plot[{0, 0, 0}, {ω, -5, 5},
  PlotStyle -> {{Color1, Dashing[{0, Small, Large, Small}]}, {Color2, Dashing[Large, Small], Thick}, {Color3, Thick}},
  PlotLegends -> {
    MaTeX["\\kappa\\epsilon_1/\\gamma_2^2 = 0.3", FontSize -> 20, "Preamble" -> {"\\usepackage{cmbright}"}],
    MaTeX["\\kappa\\epsilon_1/\\gamma_2^2 = 1.00", FontSize -> 20, "Preamble" -> {"\\usepackage{cmbright}"}],
    MaTeX["\\kappa\\epsilon_1/\\gamma_2^2 = 3.40", FontSize -> 20, "Preamble" -> {"\\usepackage{cmbright}"}]}];

In[1638]:=
Export["fig_2_legend.pdf", F2Legend];

```