

```

In[ ]:= M = 5;
      beta = 0.1;
      g = 0.;
      alpha = 0.5;
      l = 0.9;
      rz = 1;
      bVal[sigma_] = Tanh[sigma];
      r[sigma_] = sigma * rz;

      xi[z_, Delta_, OmegaA_, sign_] = M * (sign * Delta * z + OmegaA)

      betaA = alpha + beta - 1 - xi^2

      betaZ = Together[
        beta + 2 * alpha + 2 * alpha^2 * (xi^4 + 2 * g * xi^3 + 2 * g^2 * xi^2 - 5 * xi^2 - 6 * g * xi + 3) /
          ((xi^2 - 1) * (xi^4 - 6 * xi^2 - 4 * g * xi + 3))]

      nBetaZ = Numerator[betaZ]

      dBetaZ = Denominator[betaZ]

      q[z_, Delta_, OmegaA_] = ((1 - l) * nBetaZ + l * betaA * dBetaZ) / nBetaZ
      F[z_, Delta_, OmegaA_] = (Sqrt[-q[z, Delta, OmegaA] /. xi -> xi[z, Delta, OmegaA, 1]] +
        Sqrt[-q[z, Delta, OmegaA] /. xi -> xi[z, Delta, OmegaA, -1]]) / (-z^2 + 1)

Out[ ]:=
      5 (OmegaA + Delta sign z)

Out[ ]:=
      -0.4 - xi^2

Out[ ]:=
      1.1 (-1.63636 + 6.72727 xi^2 - 6.54545 xi^4 + 1. xi^6)
      -----
      (-1. + xi^2) (3. - 6. xi^2 + xi^4)

Out[ ]:=
      1.1 (-1.63636 + 6.72727 xi^2 - 6.54545 xi^4 + 1. xi^6)

Out[ ]:=
      (-1. + xi^2) (3. - 6. xi^2 + xi^4)

Out[ ]:=
      (0.909091 (0.9 (-0.4 - xi^2) (-1. + xi^2) (3. - 6. xi^2 + xi^4) +
        0.11 (-1.63636 + 6.72727 xi^2 - 6.54545 xi^4 + 1. xi^6))) /
      (-1.63636 + 6.72727 xi^2 - 6.54545 xi^4 + 1. xi^6)

```

Out[]=

$$\frac{1}{1 - z^2} \left(0.953463 \sqrt{\left(- \left(0.9 \left(-0.4 - 25 (\Omega A - \Delta z)^2 \right) \left(-1. + 25 (\Omega A - \Delta z)^2 \right) \left(3. - 150. (\Omega A - \Delta z)^2 + 625 (\Omega A - \Delta z)^4 \right) + 0.11 \left(-1.63636 + 168.182 (\Omega A - \Delta z)^2 - 4090.91 (\Omega A - \Delta z)^4 + 15625. (\Omega A - \Delta z)^6 \right) \right) / \left(-1.63636 + 168.182 (\Omega A - \Delta z)^2 - 4090.91 (\Omega A - \Delta z)^4 + 15625. (\Omega A - \Delta z)^6 \right) \right) + 0.953463 \sqrt{\left(- \left(0.9 \left(-0.4 - 25 (\Omega A + \Delta z)^2 \right) \left(-1. + 25 (\Omega A + \Delta z)^2 \right) \left(3. - 150. (\Omega A + \Delta z)^2 + 625 (\Omega A + \Delta z)^4 \right) + 0.11 \left(-1.63636 + 168.182 (\Omega A + \Delta z)^2 - 4090.91 (\Omega A + \Delta z)^4 + 15625. (\Omega A + \Delta z)^6 \right) \right) / \left(-1.63636 + 168.182 (\Omega A + \Delta z)^2 - 4090.91 (\Omega A + \Delta z)^4 + 15625. (\Omega A + \Delta z)^6 \right) \right) \right)$$

```
In[ ]:= initialOmegas = {-0.4672683793806899,
  -0.20956642019603966, -0.15600624830012666, 0.` - 0.07405849877231427` I};
deltaValues = Range[0, 1, 0.05];
sigmaLValues = {0.1, 0.3, 0.5, 1, 2, 3};

omegaValues = Table[Table[initialOmega = initialOmegas[[i]];
  initialOmega =
    OmegaA /. FindRoot[NIntegrate[F[z, Delta, OmegaA], {z, 0, bVal[sigmaL]}] == r[sigmaL],
      {OmegaA, initialOmega}], {Delta, deltaValues}],
  {i, Length[initialOmegas]}, {sigmaL, sigmaLValues}]
```

Out[]=

```
{ {{-0.467268, -0.469567 + 5.85128 × 10-14 i, 1.6587 × 10-12 - 0.0743677 i,
  -0.467268 + 3.70339 × 10-15 i, -0.467268 + 4.75655 × 10-15 i, -0.487798 - 1.99095 × 10-15 i,
  -0.467266 - 1.68568 × 10-9 i, -0.467268 + 3.91696 × 10-15 i, 3.03129 × 10-9 - 0.0786912 i,
  -0.467268 + 2.68962 × 10-15 i, -0.467268 + 4.35773 × 10-15 i, -0.467268 + 4.15618 × 10-15 i,
  -2.34845 × 10-12 + 0.0837319 i, -0.467268 + 2.77987 × 10-15 i, -8.21323 × 10-10 - 0.0866728 i,
  -0.467268 + 4.15636 × 10-15 i, -3.68826 × 10-11 - 0.0898112 i, 1.2712 × 10-14 - 0.0914406 i,
  6.28686 × 10-10 - 0.0931054 i, -0.467268 + 3.8363 × 10-15 i, -0.467268 + 4.43245 × 10-16 i},
  {-0.467268, -0.478149 + 2.18774 × 10-9 i, -0.467268 + 2.62577 × 10-15 i,
  -0.467268 + 3.603 × 10-15 i, 6.03269 × 10-9 - 0.0834957 i, -0.467268 + 3.46034 × 10-15 i,
  -0.467268 + 4.70635 × 10-15 i, -0.467268 + 3.56631 × 10-15 i, 3.42835 × 10-12 - 0.103271 i,
  -2.33995 × 10-14 + 0.109064 i, 1.24617 × 10-10 - 0.115828 i, 5.92531 × 10-9 + 0.126535 i,
  -0.467268 + 5.02775 × 10-15 i, -0.467268 + 3.38043 × 10-15 i, -0.467268 + 2.77839 × 10-15 i,
  -0.00173855 + 0.881392 i, -0.00185445 + 0.887713 i, -0.00197036 + 0.895448 i,
  0.00208626 - 0.506277 i, -0.00220216 + 0.866107 i, -0.00231807 - 0.788372 i},
  {-0.467268, -0.467268 + 2.45536 × 10-15 i, -1.34386 × 10-10 + 0.0805288 i,
  3.10212 × 10-12 - 0.0873157 i, -0.467268 + 4.91146 × 10-15 i, -9.87987 × 10-15 + 0.104106 i,
  2.75037 × 10-13 + 0.114103 i, -0.467268 + 4.04572 × 10-15 i, 2.34499 × 10-9 + 0.171825 i,
  -0.467268 + 4.80565 × 10-16 i, 0.00183861 - 0.550628 i, -0.0015988 - 0.877235 i,
  -0.00220633 + 0.724161 i, -0.00239019 - 0.670675 i, -0.467268 + 3.53656 × 10-15 i,
```

$$\begin{aligned}
& -0.467268 + 3.93304 \times 10^{-15} \text{ i}, -0.467268 + 4.98026 \times 10^{-15} \text{ i}, 0.00312563 - 0.742952 \text{ i}, \\
& 0.00169186 - 0.785132 \text{ i}, 0.0032627 - 0.763143 \text{ i}, 0.00367721 - 0.844054 \text{ i} \}, \\
& \{-0.467268, -7.15016 \times 10^{-11} - 0.0793001 \text{ i}, -9.42433 \times 10^{-10} - 0.0921115 \text{ i}, \\
& -1.35777 \times 10^{-12} + 0.108696 \text{ i}, 2.20334 \times 10^{-10} + 0.140791 \text{ i}, -0.467268 + 3.31104 \times 10^{-15} \text{ i}, \\
& -0.000909037 + 0.813063 \text{ i}, 0.00106054 - 0.861563 \text{ i}, -0.00121205 + 0.809895 \text{ i}, \\
& -0.467256 - 6.65796 \times 10^{-7} \text{ i}, 0.00151506 + 0.793715 \text{ i}, -0.00166657 + 0.881788 \text{ i}, \\
& -0.00181807 + 0.698789 \text{ i}, -0.467268 + 3.22075 \times 10^{-15} \text{ i}, 0.00200703 + 0.641368 \text{ i}, \\
& -0.00195639 + 0.585133 \text{ i}, -0.00171441 - 0.525152 \text{ i}, 0.00256782 + 0.464998 \text{ i}, \\
& -0.467365 + 2.58039 \times 10^{-15} \text{ i}, 0.0021446 + 0.370577 \text{ i}, 0.00180456 + 0.349009 \text{ i} \}, \\
& \{-0.467268, -0.467268 + 2.80366 \times 10^{-15} \text{ i}, -0.467268 + 4.18829 \times 10^{-15} \text{ i}, \\
& -1.7088 \times 10^{-12} + 0.200834 \text{ i}, 0.000767108 + 0.714985 \text{ i}, -0.00310476 + 7.9963 \times 10^{-7} \text{ i}, \\
& 0.00115066 - 0.833512 \text{ i}, -0.467268 + 3.90092 \times 10^{-15} \text{ i}, -0.00153422 + 0.696868 \text{ i}, \\
& 0.00172599 - 0.700663 \text{ i}, -0.0000141683 + 0.635688 \text{ i}, -0.467268 + 3.498 \times 10^{-15} \text{ i}, \\
& -0.00159573 + 0.281558 \text{ i}, -0.0017273 + 0.233369 \text{ i}, -0.467283 - 3.47789 \times 10^{-6} \text{ i}, \\
& -0.467343 - 3.2417 \times 10^{-15} \text{ i}, -0.00118864 - 0.218283 \text{ i}, -0.467567 + 2.68714 \times 10^{-15} \text{ i}, \\
& -0.46727 - 2.72591 \times 10^{-15} \text{ i}, -0.00336411 + 0.228964 \text{ i}, 0.00321588 + 0.233389 \text{ i} \}, \\
& \{-0.467268, -0.19843 - 2.51923 \times 10^{-15} \text{ i}, -7.75203 \times 10^{-10} + 0.127218 \text{ i}, \\
& -0.000593848 - 0.681702 \text{ i}, 0.000791797 + 0.878402 \text{ i}, 0.00402624 + 0.000044092 \text{ i}, \\
& 0.0011877 + 0.816165 \text{ i}, 0.00138564 - 0.767441 \text{ i}, -0.000832269 + 0.684303 \text{ i}, \\
& -0.467268 + 4.94637 \times 10^{-15} \text{ i}, -0.00173737 - 0.23739 \text{ i}, -0.0000911152 + 0.000149042 \text{ i}, \\
& -0.0111947 + 5.89948 \times 10^{-7} \text{ i}, 0.0011508 - 0.152743 \text{ i}, -0.467374 + 2.96657 \times 10^{-13} \text{ i}, \\
& -0.00147524 - 0.171389 \text{ i}, -0.467299 + 1.22025 \times 10^{-6} \text{ i}, -0.0012246 + 0.189583 \text{ i}, \\
& -0.467332 + 4.88356 \times 10^{-9} \text{ i}, -0.467401 - 0.0000118124 \text{ i}, -0.467308 + 3.90429 \times 10^{-15} \text{ i} \} \}, \\
& \{-0.209566, -0.209986, -0.211475 + 1.23192 \times 10^{-9} \text{ i}, -0.213641 - 2.9352 \times 10^{-15} \text{ i}, \\
& -0.215793 - 2.32433 \times 10^{-15} \text{ i}, -0.218321 - 1.69711 \times 10^{-15} \text{ i}, -0.209566 + 2.59376 \times 10^{-15} \text{ i}, \\
& -0.209566 + 2.50815 \times 10^{-15} \text{ i}, -0.209566 + 2.84339 \times 10^{-15} \text{ i}, -0.209566 + 3.30148 \times 10^{-15} \text{ i}, \\
& -0.209562 + 2.53796 \times 10^{-15} \text{ i}, -0.209566 + 4.08167 \times 10^{-15} \text{ i}, -0.209566 + 1.98883 \times 10^{-15} \text{ i}, \\
& -0.205487 - 0.0000639581 \text{ i}, -0.209548 - 3.09993 \times 10^{-15} \text{ i}, -0.209566 + 3.75031 \times 10^{-15} \text{ i}, \\
& -0.209566 + 2.56041 \times 10^{-15} \text{ i}, -0.209566 + 2.90074 \times 10^{-15} \text{ i}, -0.223298 + 3.15554 \times 10^{-12} \text{ i}, \\
& -0.209566 + 2.33043 \times 10^{-15} \text{ i}, -0.209566 + 2.99876 \times 10^{-15} \text{ i} \}, \\
& \{-0.209566, -0.213543 - 2.28174 \times 10^{-15} \text{ i}, -0.209566 + 3.7326 \times 10^{-15} \text{ i}, \\
& -0.209566 + 3.51923 \times 10^{-15} \text{ i}, -0.209566 + 2.39923 \times 10^{-15} \text{ i}, -0.209566 + 3.21068 \times 10^{-15} \text{ i}, \\
& -0.217177 - 4.70863 \times 10^{-14} \text{ i}, -0.230485 - 2.44131 \times 10^{-10} \text{ i}, -0.209566 + 2.16565 \times 10^{-15} \text{ i}, \\
& -0.209566 + 2.72721 \times 10^{-15} \text{ i}, -0.209553 - 1.08244 \times 10^{-15} \text{ i}, 5.92531 \times 10^{-9} - 0.126535 \text{ i}, \\
& 8.72837 \times 10^{-12} + 0.143152 \text{ i}, 3.3001 \times 10^{-11} + 0.170985 \text{ i}, -0.209566 + 2.1788 \times 10^{-15} \text{ i}, \\
& -0.209566 + 3.44871 \times 10^{-15} \text{ i}, -0.209566 + 2.47141 \times 10^{-15} \text{ i}, 0.00197036 - 0.719554 \text{ i}, \\
& -0.209566 + 2.90029 \times 10^{-15} \text{ i}, -0.209566 + 3.35309 \times 10^{-15} \text{ i}, 0.00231807 - 0.788532 \text{ i} \}, \\
& \{-0.209566, -0.217866 - 1.57448 \times 10^{-15} \text{ i}, -0.191751 + 2.33195 \times 10^{-15} \text{ i}, \\
& -0.209166 - 2.95421 \times 10^{-8} \text{ i}, -0.209566 + 3.6785 \times 10^{-15} \text{ i}, -0.209566 + 3.08348 \times 10^{-15} \text{ i}, \\
& -0.209555 + 2.53057 \times 10^{-15} \text{ i}, -0.209566 + 1.99116 \times 10^{-15} \text{ i}, 5.12004 \times 10^{-9} - 0.171825 \text{ i}, \\
& 2.10055 \times 10^{-7} - 0.325096 \text{ i}, -0.209566 + 2.29613 \times 10^{-15} \text{ i}, -0.00202247 + 0.570483 \text{ i}, \\
& -0.209566 + 2.54086 \times 10^{-15} \text{ i}, -0.209566 + 3.27477 \times 10^{-15} \text{ i}, 0.00257405 - 0.822569 \text{ i}, \\
& -0.00275791 - 0.713817 \text{ i}, -0.00207004 + 0.818974 \text{ i}, -0.00312563 - 0.757385 \text{ i}, \\
& 0.00330949 - 0.765793 \text{ i}, 0.00260805 + 0.75949 \text{ i}, 0.00367721 - 0.859595 \text{ i} \}, \\
& \{-0.209566, -0.209566 + 3.11185 \times 10^{-15} \text{ i}, -0.209566 + 2.65327 \times 10^{-15} \text{ i},
\end{aligned}$$

$$\begin{aligned}
& -1.04977 \times 10^{-12} + 0.108696 \, i, -0.209566 + 3.29739 \times 10^{-15} \, i, -0.209566 + 4.0062 \times 10^{-15} \, i, \\
& -0.000909037 + 0.79953 \, i, -0.209556 - 2.49488 \times 10^{-15} \, i, 0.00121205 - 0.932704 \, i, \\
& -0.00136356 + 0.82132 \, i, -0.00151506 + 0.78754 \, i, 0.00166657 + 0.761611 \, i, \\
& -0.00181807 - 0.666658 \, i, 0.000125314 - 0.68617 \, i, -0.00212109 - 0.600739 \, i, \\
& -0.00166962 + 0.584933 \, i, 0.00157229 + 0.525311 \, i, -0.0000403877 + 0.465589 \, i, \\
& -0.00140158 + 0.409866 \, i, -0.00237116 + 0.37853 \, i, -0.00298999 + 0.352966 \, i \}, \\
& \{-0.209566, -0.196558 - 3.1657 \times 10^{-15} \, i, -0.209566 + 3.35243 \times 10^{-15} \, i, \\
& -8.05811 \times 10^{-9} + 0.200834 \, i, -0.0318238 + 2.0749 \times 10^{-15} \, i, -0.00180724 - 5.61391 \times 10^{-6} \, i, \\
& -0.209566 + 3.19447 \times 10^{-15} \, i, 0.00134244 + 0.767733 \, i, 0.00153422 + 0.746944 \, i, \\
& 0.00135373 + 0.682078 \, i, -0.0000458886 + 0.590164 \, i, 0.00162335 + 0.446518 \, i, \\
& 0.00164196 + 0.284294 \, i, -0.209573 - 2.91734 \times 10^{-6} \, i, 0.00243074 - 0.218212 \, i, \\
& 0.00152677 - 0.215835 \, i, -0.209576 - 7.4596 \times 10^{-7} \, i, 0.00245271 + 0.221509 \, i, \\
& 0.00338345 + 0.2237 \, i, -0.209574 - 3.86628 \times 10^{-16} \, i, -0.00300723 + 0.233079 \, i \}, \\
& \{-0.209566, -0.198364 - 1.83585 \times 10^{-15} \, i, -0.0587085 + 2.03697 \times 10^{-10} \, i, \\
& -0.000593848 - 0.863773 \, i, -0.209568 + 2.05275 \times 10^{-15} \, i, -0.209566 + 2.81803 \times 10^{-15} \, i, \\
& 0.0011877 + 0.80986 \, i, -0.00138564 - 0.756515 \, i, -0.171421 + 3.4953 \times 10^{-15} \, i, \\
& 0.00178154 + 0.526677 \, i, -0.209493 + 3.51033 \times 10^{-6} \, i, 0.00120762 - 0.163579 \, i, \\
& 0.0998899 - 7.97282 \times 10^{-6} \, i, -0.000695705 + 0.152705 \, i, -0.209552 - 9.40814 \times 10^{-12} \, i, \\
& -0.209598 + 1.94242 \times 10^{-15} \, i, -0.209567 + 2.68941 \times 10^{-12} \, i, -0.00137426 + 0.189281 \, i, \\
& -0.209874 + 2.95609 \times 10^{-15} \, i, -0.00259752 + 0.203492 \, i, 0.00366569 + 0.210609 \, i \}, \\
& \{-0.156006, -0.1564, -0.15778 + 1.61741 \times 10^{-15} \, i, -0.15855 - 0.0000307697 \, i, \\
& -0.156006 + 2.10961 \times 10^{-15} \, i, -0.156006 + 2.62925 \times 10^{-15} \, i, \\
& -0.156006 + 3.57387 \times 10^{-15} \, i, -0.224945 + 0.000030443 \, i, -0.189868 + 2.3383 \times 10^{-15} \, i, \\
& -0.192402 + 2.72779 \times 10^{-15} \, i, -0.156006 + 2.40398 \times 10^{-15} \, i, -0.156006 + 3.36794 \times 10^{-15} \, i, \\
& -0.156006 + 2.05207 \times 10^{-15} \, i, -0.156006 + 3.31727 \times 10^{-15} \, i, -0.156006 + 2.97046 \times 10^{-15} \, i, \\
& -0.156006 + 2.66299 \times 10^{-15} \, i, -0.156006 + 3.84144 \times 10^{-15} \, i, -0.156006 + 1.97059 \times 10^{-15} \, i, \\
& -0.156006 + 2.37264 \times 10^{-15} \, i, -0.156014 - 1.5919 \times 10^{-15} \, i, -0.156006 + 1.7801 \times 10^{-15} \, i \}, \\
& \{-0.156006, -0.15799 - 4.8256 \times 10^{-7} \, i, -0.153408 - 5.22186 \times 10^{-6} \, i, \\
& -0.156006 + 4.01768 \times 10^{-15} \, i, -0.156006 + 2.83753 \times 10^{-15} \, i, -0.156006 + 2.44212 \times 10^{-15} \, i, \\
& -0.156006 + 2.64483 \times 10^{-15} \, i, -0.156006 + 1.96596 \times 10^{-15} \, i, -1.25955 \times 10^{-9} - 0.103271 \, i, \\
& -0.156006 + 2.3672 \times 10^{-15} \, i, -0.156006 + 2.37196 \times 10^{-15} \, i, -0.156006 + 2.38683 \times 10^{-15} \, i, \\
& -0.156006 + 4.0559 \times 10^{-15} \, i, -0.155992 - 3.25091 \times 10^{-15} \, i, -0.156006 + 3.72292 \times 10^{-15} \, i, \\
& -0.156006 + 2.75413 \times 10^{-15} \, i, -0.00185445 - 0.394279 \, i, 0.00197036 - 0.74845 \, i, \\
& -0.15599 + 1.59803 \times 10^{-15} \, i, -0.00220216 + 0.874201 \, i, -0.00231807 + 0.634782 \, i \}, \\
& \{-0.156006, -0.156006 + 2.64344 \times 10^{-15} \, i, -0.192853 - 2.82925 \times 10^{-15} \, i, \\
& -0.156006 + 3.56288 \times 10^{-15} \, i, -0.156006 + 2.58299 \times 10^{-15} \, i, -0.156006 + 3.06786 \times 10^{-15} \, i, \\
& -0.156006 + 3.08592 \times 10^{-15} \, i, -0.156006 + 3.22405 \times 10^{-15} \, i, -0.156004 + 1.56819 \times 10^{-12} \, i, \\
& -1.19613 \times 10^{-9} - 0.325096 \, i, -0.156006 + 2.38996 \times 10^{-15} \, i, -0.156006 + 2.28951 \times 10^{-15} \, i, \\
& -0.00220633 + 0.55824 \, i, 0.00178491 + 0.862177 \, i, 0.00257405 + 0.670267 \, i, \\
& -0.00275791 - 0.678305 \, i, 0.00294177 - 0.880719 \, i, 0.00312563 - 0.828252 \, i, \\
& -0.00330949 - 0.746961 \, i, -0.00317861 + 0.768217 \, i, 0.00294952 + 0.721376 \, i \}, \\
& \{-0.156006, -0.156006 + 2.03244 \times 10^{-15} \, i, -0.156006 + 2.48019 \times 10^{-15} \, i, \\
& -0.156006 + 3.21677 \times 10^{-15} \, i, -1.22228 \times 10^{-12} + 0.140791 \, i, -0.156006 + 3.18928 \times 10^{-15} \, i, \\
& -0.156002 - 5.26683 \times 10^{-16} \, i, -0.156006 + 1.73063 \times 10^{-15} \, i, -0.00121205 - 0.828409 \, i, \\
& 0.00136356 - 0.80914 \, i, 0.00151506 - 0.802975 \, i, 0.00166657 + 0.730113 \, i,
\end{aligned}$$

$0.00181807 - 0.699856 \text{ i}, 0.00196958 + 0.685741 \text{ i}, -0.00172461 - 0.637701 \text{ i},$
 $0.00200191 + 0.584157 \text{ i}, 0.001634 + 0.52397 \text{ i}, 0.00189328 + 0.46576 \text{ i},$
 $-0.156012 - 1.14335 \times 10^{-8} \text{ i}, 0.0021193 + 0.368465 \text{ i}, -0.156044 + 1.38569 \times 10^{-9} \text{ i}\},$
 $\{-0.156006, -0.156006 + 2.66968 \times 10^{-15} \text{ i}, 2.36554 \times 10^{-12} + 0.111195 \text{ i},$
 $7.82544 \times 10^{-9} - 0.200834 \text{ i}, -0.000767108 - 0.818108 \text{ i}, -0.156006 + 2.86691 \times 10^{-15} \text{ i},$
 $0.00115066 - 0.825247 \text{ i}, -0.00134244 + 0.796805 \text{ i}, 0.000901033 + 0.747224 \text{ i},$
 $0.00172599 + 0.628415 \text{ i}, 0.00191777 - 0.603565 \text{ i}, -0.00166544 - 0.433089 \text{ i},$
 $0.00169995 + 0.291641 \text{ i}, -0.156008 - 1.58555 \times 10^{-7} \text{ i}, -0.156067 - 0.0000184988 \text{ i},$
 $-0.00270445 + 0.213725 \text{ i}, -0.00259401 + 0.221013 \text{ i}, -0.00305783 + 0.223222 \text{ i},$
 $-0.002544 + 0.224808 \text{ i}, 0.00251631 + 0.229789 \text{ i}, -0.00287761 + 0.232524 \text{ i}\},$
 $\{-0.156006, -0.156006 + 1.95963 \times 10^{-15} \text{ i}, 1.31362 \times 10^{-10} - 0.127218 \text{ i},$
 $0.0000921523 + 1.69779 \times 10^{-15} \text{ i}, 1.29124 \times 10^{-6} + 0.0000234669 \text{ i}, -0.156006 + 2.61145 \times 10^{-15} \text{ i},$
 $-0.0011877 - 0.810196 \text{ i}, -0.137141 - 0.000010646 \text{ i}, 0.00158359 + 0.678544 \text{ i},$
 $-0.00178154 - 0.512092 \text{ i}, 0.00121025 - 0.239411 \text{ i}, 0.00118015 + 0.164331 \text{ i},$
 $0.000568522 + 0.147338 \text{ i}, -0.000636293 - 0.152218 \text{ i}, 0.00131703 + 0.161878 \text{ i},$
 $-0.00065878 + 0.171312 \text{ i}, -0.156006 + 6.49428 \times 10^{-10} \text{ i}, 0.00142403 - 0.189401 \text{ i},$
 $-0.156006 - 6.50402 \times 10^{-16} \text{ i}, -0.00268479 + 0.202997 \text{ i}, 0.00322889 + 0.211377 \text{ i}\}\},$
 $\{ \{0. - 0.0740585 \text{ i}, 0. - 0.0741361 \text{ i}, 0. - 0.0743677 \text{ i}, 0. - 0.0747502 \text{ i}, 0. - 0.0752782 \text{ i},$
 $0. - 0.0759449 \text{ i}, 0. - 0.0767421 \text{ i}, 0. - 0.0776608 \text{ i}, 0. - 0.0786912 \text{ i},$
 $0. - 0.0798234 \text{ i}, 0. - 0.0810474 \text{ i}, 0. - 0.0823533 \text{ i}, 0. - 0.0837319 \text{ i},$
 $0. - 0.0851744 \text{ i}, 0. - 0.0866728 \text{ i}, 0. - 0.0882204 \text{ i}, 0. - 0.0898112 \text{ i},$
 $0. - 0.0914406 \text{ i}, 0. - 0.0931054 \text{ i}, 0. - 0.0948033 \text{ i}, -1.68083 \times 10^{-19} - 0.0965336 \text{ i}\},$
 $\{0. - 0.0740585 \text{ i}, 0. - 0.0747292 \text{ i}, 0. - 0.0766648 \text{ i}, 0. - 0.0796694 \text{ i},$
 $0. - 0.0834957 \text{ i}, 0. - 0.0879066 \text{ i}, 0. - 0.0927215 \text{ i}, 0. - 0.0978447 \text{ i},$
 $0. - 0.103271 \text{ i}, 0. - 0.109064 \text{ i}, 0. - 0.115828 \text{ i}, 0. - 0.126535 \text{ i},$
 $0. - 0.143152 \text{ i}, 0. - 0.170985 \text{ i}, 0. - 0.22803 \text{ i}, 0. - 0.890563 \text{ i}, 0. - 0.885561 \text{ i},$
 $0. - 0.880206 \text{ i}, 0. - 0.874527 \text{ i}, 0. - 0.868413 \text{ i}, 1.03936 \times 10^{-8} - 0.861936 \text{ i}\},$
 $\{0. - 0.0740585 \text{ i}, 0. - 0.0757878 \text{ i}, 0. - 0.0805288 \text{ i}, 0. - 0.0873157 \text{ i},$
 $0. - 0.0952908 \text{ i}, 0. - 0.104106 \text{ i}, 0. - 0.114103 \text{ i}, 0. - 0.132441 \text{ i},$
 $0. - 0.171825 \text{ i}, 0. - 0.325096 \text{ i}, 0. - 0.885224 \text{ i}, 0. - 0.876388 \text{ i},$
 $0. + 0.866566 \text{ i}, 0. + 0.855852 \text{ i}, 0. - 0.844055 \text{ i}, 0. + 0.831209 \text{ i}, 0. - 0.817355 \text{ i},$
 $0. - 0.80218 \text{ i}, 0. - 0.785937 \text{ i}, 0. - 0.768772 \text{ i}, 1.15951 \times 10^{-12} - 0.749835 \text{ i}\},$
 $\{0. - 0.0740585 \text{ i}, 0. - 0.0793001 \text{ i}, 0. - 0.0921115 \text{ i}, 0. - 0.108696 \text{ i},$
 $0. - 0.140791 \text{ i}, 0. - 0.342332 \text{ i}, 0. - 0.881847 \text{ i}, 0. + 0.865187 \text{ i},$
 $0. - 0.845271 \text{ i}, 0. - 0.822225 \text{ i}, 0. - 0.79512 \text{ i}, 0. - 0.764022 \text{ i},$
 $0. - 0.728011 \text{ i}, 0. - 0.686492 \text{ i}, 0. + 0.638548 \text{ i}, 0. - 0.584494 \text{ i}, 0. - 0.525 \text{ i},$
 $0. - 0.46557 \text{ i}, 0. - 0.414977 \text{ i}, 0. + 0.377146 \text{ i}, 3.2724 \times 10^{-10} + 0.351627 \text{ i}\},$
 $\{0. - 0.0740585 \text{ i}, 0. - 0.0851688 \text{ i}, 0. - 0.111195 \text{ i}, 0. - 0.200834 \text{ i}, 0. - 0.88738 \text{ i},$
 $0. - 0.864064 \text{ i}, 0. + 0.834371 \text{ i}, 0. + 0.796157 \text{ i}, 0. + 0.746748 \text{ i},$
 $0. - 0.681925 \text{ i}, 0. - 0.589884 \text{ i}, 0. + 0.435116 \text{ i}, 0. - 0.285809 \text{ i},$
 $0. - 0.235022 \text{ i}, 0. - 0.219701 \text{ i}, 0. - 0.217044 \text{ i}, 0. - 0.218981 \text{ i},$
 $0. - 0.222711 \text{ i}, 0. - 0.227004 \text{ i}, 0. - 0.231547 \text{ i}, 3.94338 \times 10^{-7} - 0.23583 \text{ i}\},$
 $\{0. - 0.0740585 \text{ i}, 0. - 0.0884953 \text{ i}, 0. - 0.127218 \text{ i}, 0. + 0.0000242436 \text{ i},$
 $0. - 0.878497 \text{ i}, 0. + 1.94516 \times 10^{-15} \text{ i}, 0. - 0.810476 \text{ i}, 0. - 0.758 \text{ i},$
 $0. - 0.683887 \text{ i}, 0. - 0.556023 \text{ i}, 0. + 0.0000881312 \text{ i}, 0. + 2.36249 \times 10^{-15} \text{ i},$

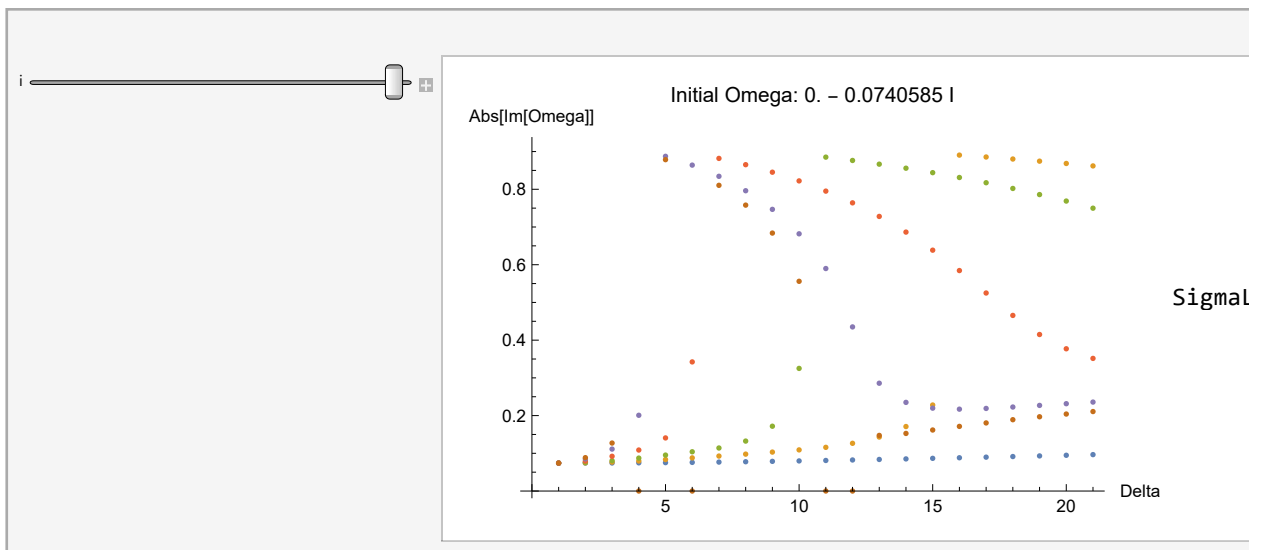
```
0. + 0.147449 i, 0. + 0.152718 i, 0. + 0.161794 i, 0. + 0.171374 i, 0. + 0.180554 i,
0. - 0.189116 i, 0. + 0.196896 i, 0. + 0.204125 i,  $-6.36441 \times 10^{-13} + 0.210724 i$  } }
```

```
In[ ]:= Manipulate[ListPlot[Abs[Im[omegaValues[[i]]]],
  PlotLabel -> "Initial Omega: " <> ToString[initialOmegas[[i]]],
  AxesLabel -> {"Delta", "Abs[Im[Omega]]"},
  PlotLegends -> StringJoin["Signal: ", ToString[#]] & /@ signalValues],
{i, 1, Length[initialOmegas], 1}, PointSize[large]]
```

Manipulate: Manipulate argument PointSize[large] does not have the correct form for a variable specification.

Out[]:=

```
Manipulate[ListPlot[Abs[Im[omegaValues[[i]]]],
  PlotLabel -> Initial Omega: <> ToString[initialOmegas[[i]]],
  AxesLabel -> {Delta, Abs[Im[Omega]]},
  (PlotLegends -> Signal: <> ToString[#1] &) /@ signalValues],
{i, 1, Length[initialOmegas], 1}, PointSize[large]]
```



```

In[*]:= (*New code to generate interpolated data*)interpolatedData =
  Table[Interpolation[{deltaValues, Abs[Im[omegaValues[[i, j]]]} // Transpose,
    InterpolationOrder → 3], {i, Length[initialOmegas]}, {j, Length[sigmaLValues]}}];

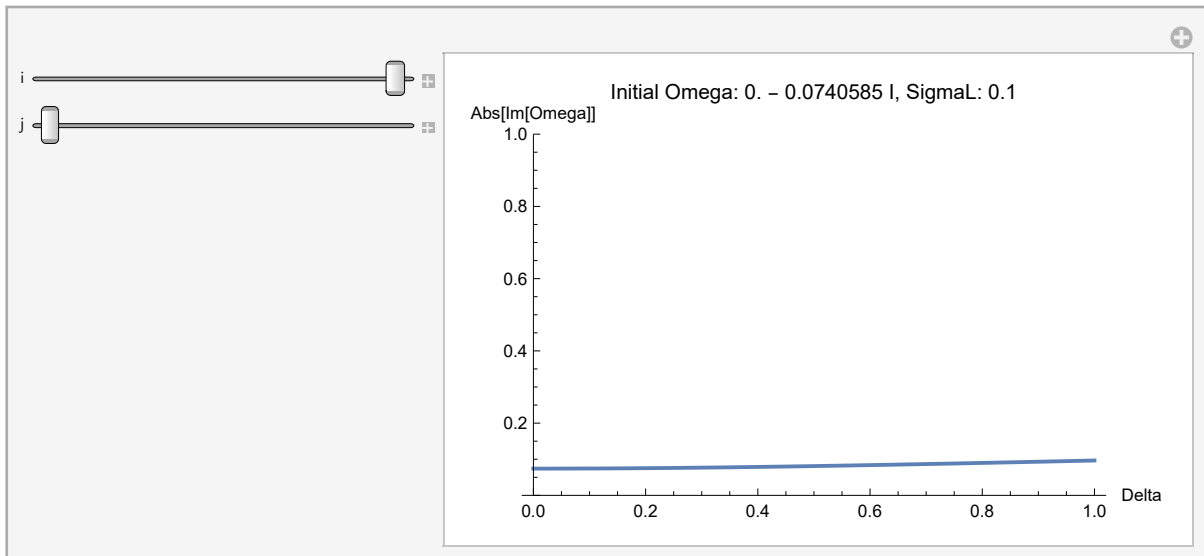
```

```

(*New code to generate interactive plots with interpolation*)
Manipulate[Plot[interpolatedData[[i, j]][x],
  {x, Min[deltaValues], Max[deltaValues]}, PlotRange → {0, 1},
  AxesLabel → {"Delta", "Abs[Im[Omega]]"}, PlotLabel → StringJoin["Initial Omega: ",
    ToString[initialOmegas[[i]], ", SigmaL: ", ToString[sigmaLValues[[j]]]],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

```

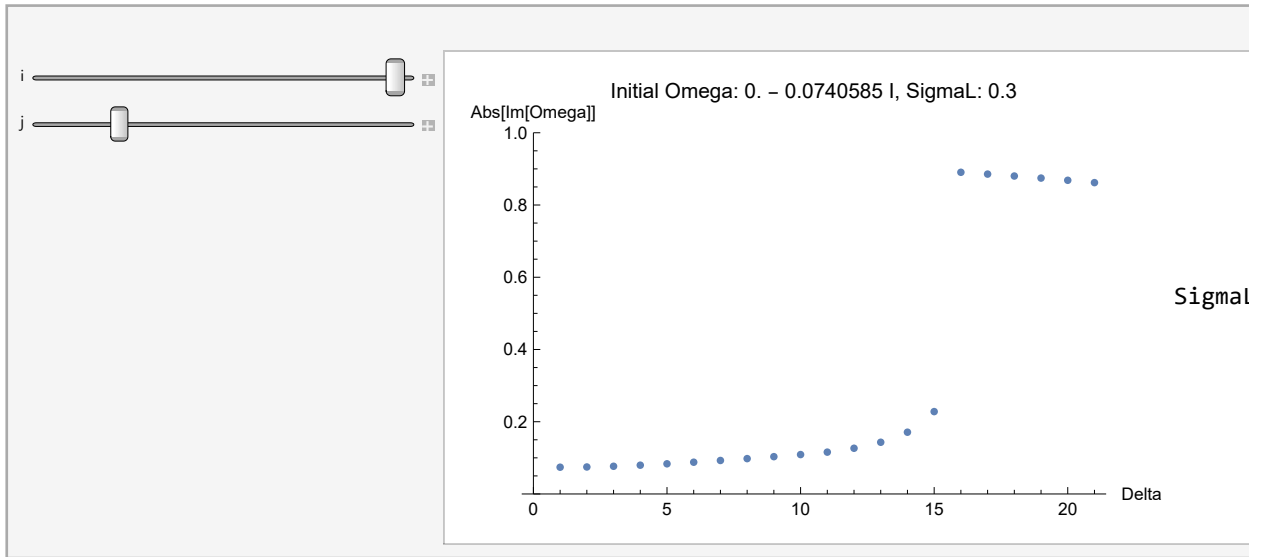
Out[*]=



```

In[*]:= Manipulate[ListPlot[Abs[Im[omegaValues[[i, j]]]],
  PlotLabel → "Initial Omega: " <> ToString[initialOmegas[[i]] <> ", SigmaL: " <>
    ToString[sigmaLValues[[j]], PlotRange → {0, 1}, AxesLabel → {"Delta", "Abs[Im[Omega]]"},
  PlotLegends → StringJoin["SigmaL: ", ToString[#]] & /@ sigmaLValues],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

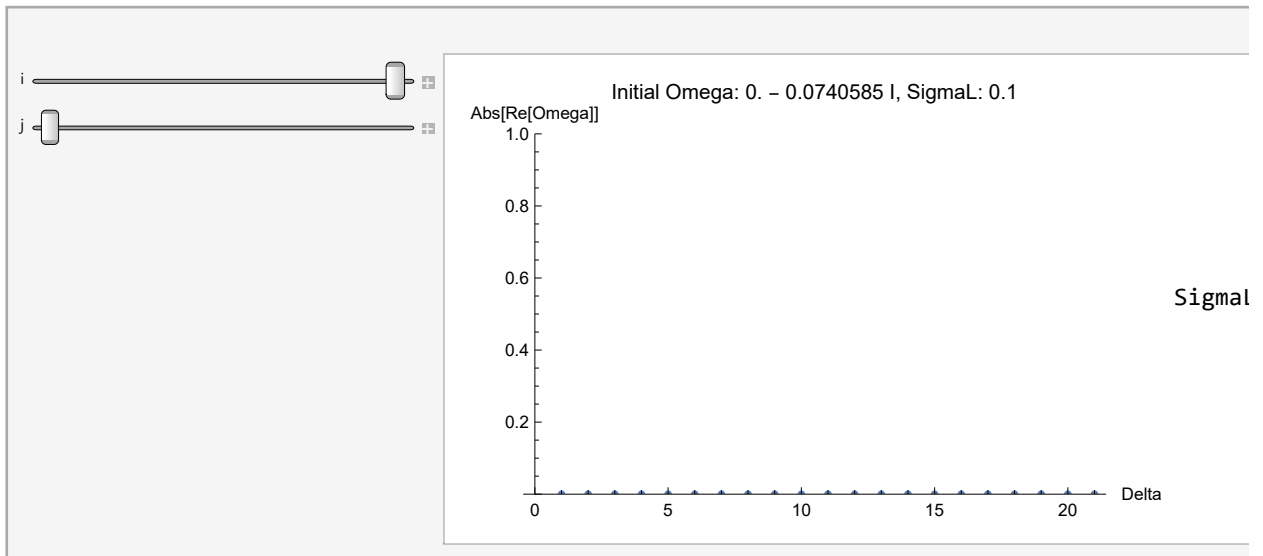
```



```

In[ ]:= Manipulate[ListPlot[Abs[Re[omegaValues[[i, j]]], PlotRange -> {0, 1},
  PlotLabel -> "Initial Omega: " <> ToString[initialOmegas[[i]]] <> ", Signal: " <>
    ToString[sigmaLValues[[j]], AxesLabel -> {"Delta", "Abs[Re[Omega]]"},
  PlotLegends -> StringJoin["SignalL: ", ToString[#]] & /@ sigmaLValues],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

```

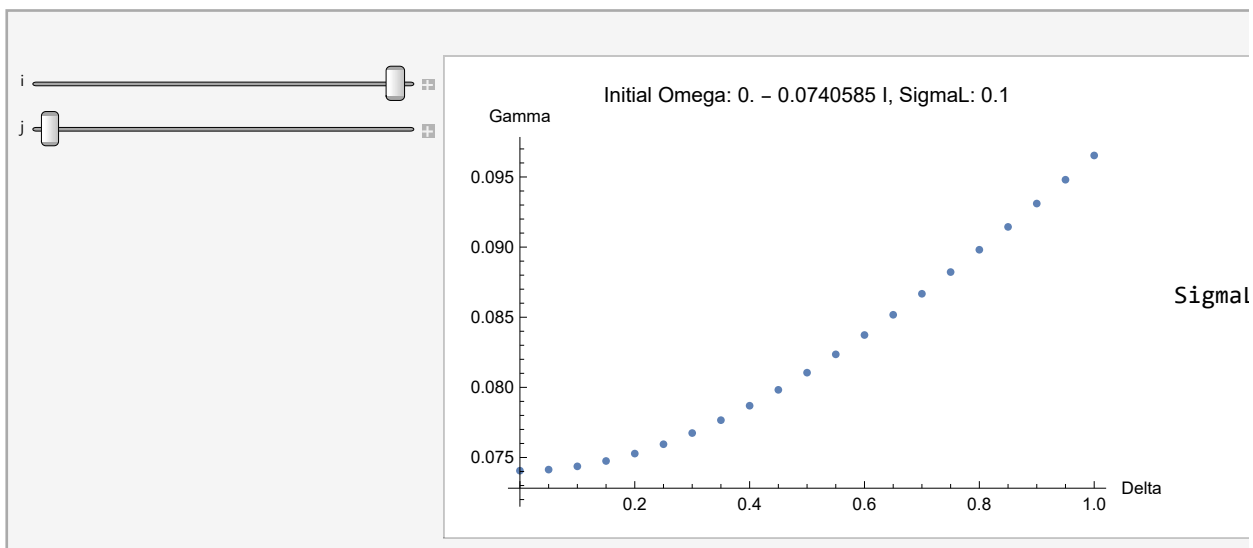
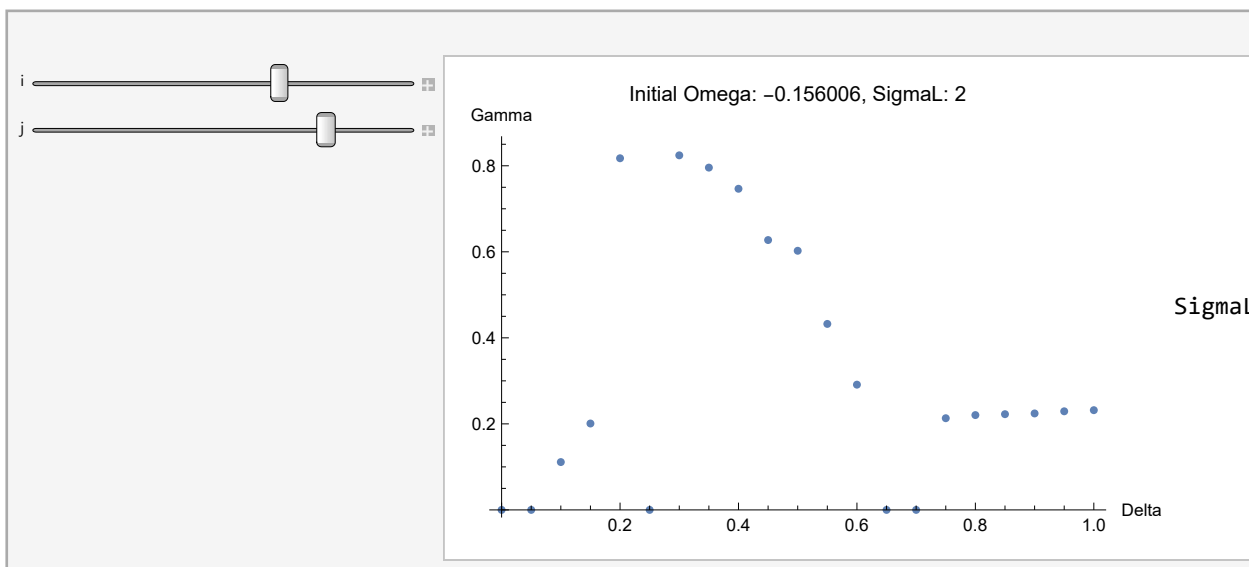



```

In[ ]:= Manipulate[ListPlot[
  {deltaValues, Abs[Im[omegaValues[[i, j]]] / (1 + Abs[Re[omegaValues[[i, j]]])} // Transpose,
  PlotLabel -> "Initial Omega: " <> ToString[initialOmegas[[i]]] <>
    ", SigmaL: " <> ToString[sigmaLValues[[j]], AxesLabel -> {"Delta", "Gamma"},
  PlotLegends -> StringJoin["SigmaL: ", ToString[#]] & /@ sigmaLValues],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

```

Out[]:=

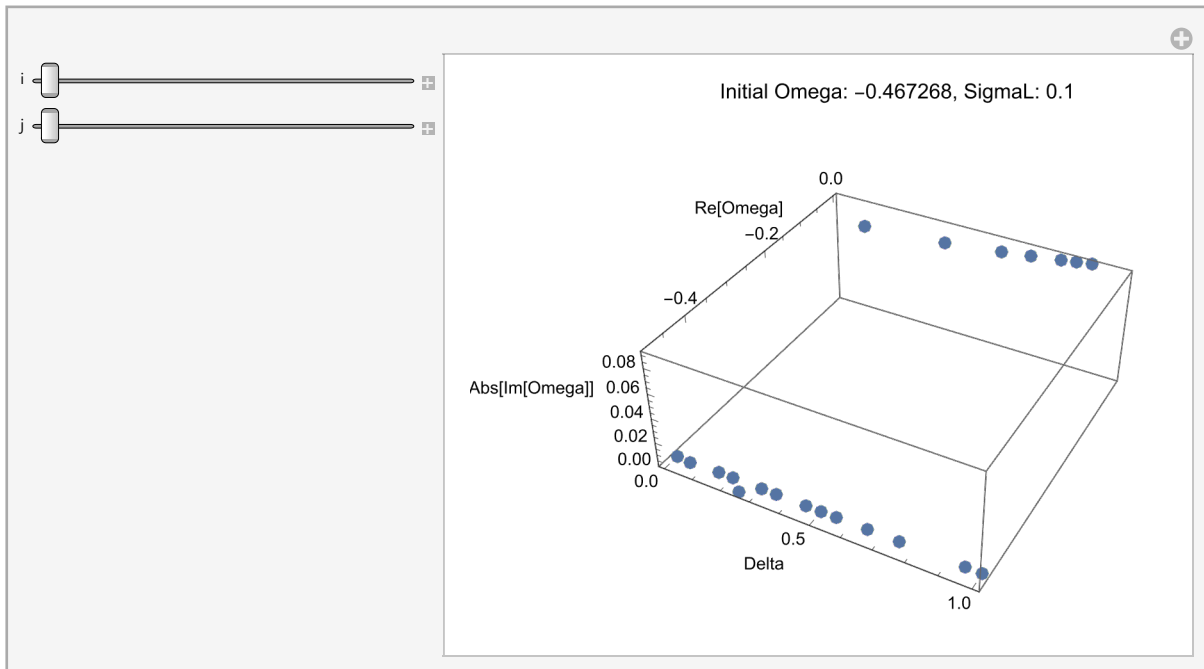


```

In[ ]:= Manipulate[ListPointPlot3D[
  {{deltaValues, Re[omegaValues[[i, j]], Abs[Im[omegaValues[[i, j]]]} // Transpose},
  PlotStyle -> {PointSize[Large]}, AxesLabel -> {"Delta", "Re[Omega]", "Abs[Im[Omega]]"},
  PlotLabel -> StringJoin["Initial Omega: ",
    ToString[initialOmegas[[i]], " ", SigmaL: " ", ToString[sigmaLValues[[j]]]],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

```

Out[]=

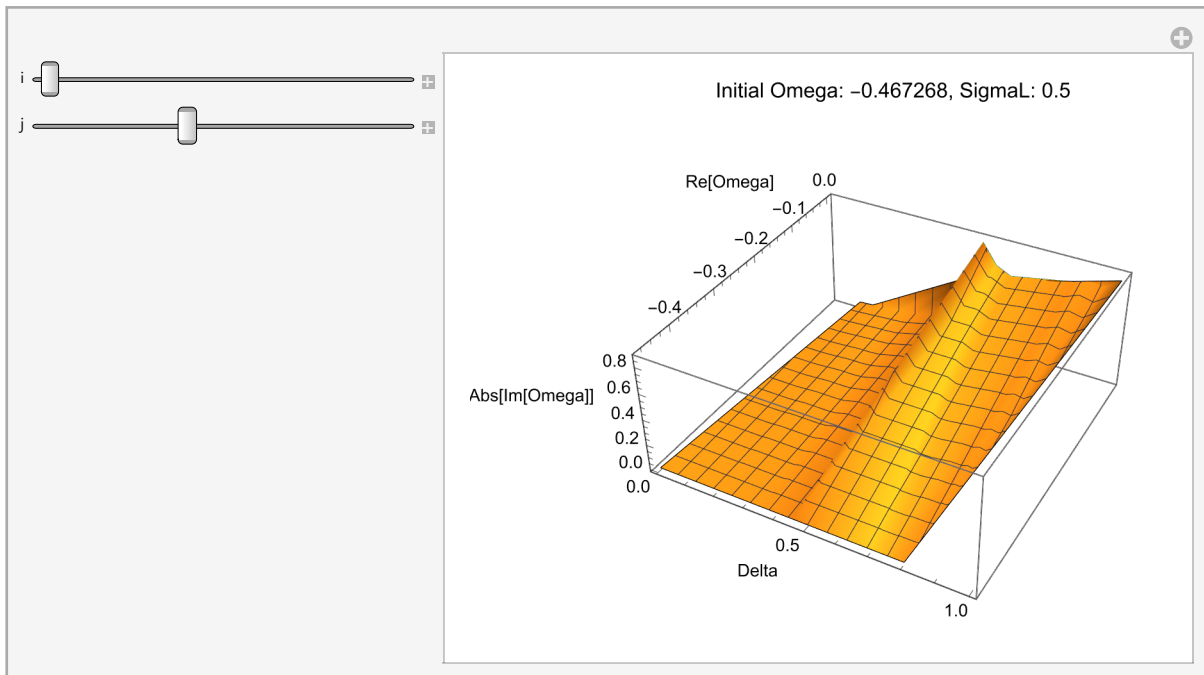


```

In[ ]:= Manipulate[ListPlot3D[
  {{deltaValues, Re[omegaValues[[i, j]], Abs[Im[omegaValues[[i, j]]]} // Transpose},
  PlotStyle -> {PointSize[Large]}, AxesLabel -> {"Delta", "Re[Omega]", "Abs[Im[Omega]]"},
  PlotLabel -> StringJoin["Initial Omega: ",
    ToString[initialOmegas[[i]], " ", SigmaL: ", ToString[sigmaLValues[[j]]]],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

```

Out[]=



```

In[ ]:= Manipulate[ListPlot3D[
  {{deltaValues, Abs[Re[omegaValues[[i, j]]], Abs[Im[omegaValues[[i, j]]]} // Transpose},
  PlotRange -> {{0, 1}, {0, 1}, {0, 1}},
  AxesLabel -> {"Delta", "Re[Omega]", "Abs[Im[Omega]]"},
  PlotLabel -> StringJoin["Initial Omega: ",
    ToString[initialOmegas[[i]], " ", SigmaL: ", ToString[sigmaLValues[[j]]]],
  {i, 1, Length[initialOmegas], 1}, {j, 1, Length[sigmaLValues], 1}]

```

Out[]=

