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In[*]:= (* Can gdi be negative due to the existence of a ghost species?
Q matrix for IM with 2 species, 2 sequences.
The states are 11, 12, 22, 1|2.
Consider species tree ((B,A),C), with gene flow from C→A at the rate MCA.
Node ages are tauABC> tauAB.
GDI is defined using a1, a2, b, and gene tree G1 is ((a1,a2),b).
A 4-state Markov chain is used to describe the history of a1 a2 up to time tauAB.
In the Markov chain 1=A, 2=C, so that thetaA=thetaA, thetaC=thetaC.

*)
θ3 = 2; dtau = 0.2; θ12 = 0.04;
Q[M_] := Block[{θ1, θ3, c1, c3, M31, w31},
  θ1 = θ3; M31 = M;
  c1 = 2 / θ1; c3 = 2 / θ3; w31 = 4 M31 / θ1;

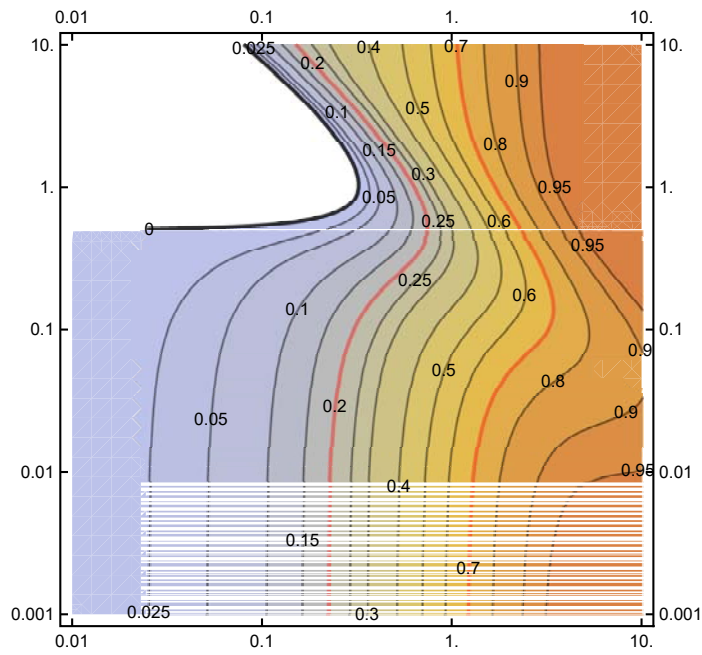
  {{-(2 * w31 + c1), 2 * w31, 0, c1},
   {0, -w31, w31, 0},
   {0, 0, -c3, c3},
   {0, 0, 0, 0}}
];
PG1a[τ_, M_] := Block[{P},
  P = MatrixExp[Q[M] * τ];
  P[[1, 4]]
];
PG1[τ_, M_] := Block[{P, θ12, θ3, dtau},
  P = MatrixExp[Q[M] * τ];
  P[[1, 1]] / 3 + P[[1, 2]] * Exp[-(2 * dtau / θ12)] / 3
  + P[[1, 3]] * (1 - 2 / 3 * Exp[-2 * dtau / θ3]) + P[[1, 4]]
];

In[*]:= b = 10; Mmin = 0.001; Mmax = 10; τmin = 0.01; τmax = 10;
newStyle[x_] := x /. l_Line -> Sequence[Opacity[.4], Thick, Red, 1]
newStyle2[x_] := x /. l_Line -> Sequence[Opacity[.8], Thick, Black, 1]
ContourPlot[(PG1[b^τ, b^M] - 1/3) * 3/2,
  {τ, Log[b, τmin], Log[b, τmax]}, {M, Log[b, Mmin], Log[b, Mmax]},
  Contours -> {0, 0.025, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95},
  (* ContourStyle -> {{Red, Thin}}, *)
  BaseStyle -> {FontFamily -> "Arial", FontSize -> 9}, PlotPoints -> 30, ContourLabels -> All,
  ColorFunction -> (ColorData[{"BeachColors", "Reverse"}]), ContourStyle -> Thin, AspectRatio -> 1,
  (* Frame -> False, *)
  FrameTicks -> {Table[{τ, ToString[Round[b^τ, τmin]]}, {τ, Log[b, τmin], Log[b, τmax]}],
    Table[{M, ToString[Round[b^M, Mmin]]}, {M, Log[b, Mmin], Log[b, Mmax]}]}
] /. Tooltip[x_, 0.2] -> Tooltip[newStyle[x], 0.2] /.
Tooltip[x_, 0.7] -> Tooltip[newStyle[x], 0.7] /. Tooltip[x_, 0] -> Tooltip[newStyle2[x], 0]

ContourPlot[PG1a[b^τ, b^M], {τ, Log[b, τmin], Log[b, τmax]}, {M, Log[b, Mmin], Log[b, Mmax]},
  Contours -> {0, 0.025, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95},
  BaseStyle -> {FontFamily -> "Arial", FontSize -> 9}, PlotPoints -> 30, ContourLabels -> All,
  ColorFunction -> (ColorData[{"BeachColors", "Reverse"}]), ContourStyle -> Thin, AspectRatio -> 1,
  (* Frame -> False, *)
  FrameTicks -> {Table[{τ, ToString[Round[b^τ, τmin]]}, {τ, Log[b, τmin], Log[b, τmax]}],
    Table[{M, ToString[Round[b^M, Mmin]]}, {M, Log[b, Mmin], Log[b, Mmax]}]}
] /. Tooltip[x_, 0.2] -> Tooltip[newStyle[x], 0.2] /.
Tooltip[x_, 0.7] -> Tooltip[newStyle[x], 0.7]

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Out[8]=



Out[9]=

