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(* (c) 2009 Andisheh Mahdavi *)
(* This Mathematica Notebook calculates the orbit of a particle for the equatorial theta=
 Pi/2 plane in Hartle's wormhole metric under the assumption t=tau. This assumption,
while not strictly correct, gives the correct shape for the orbit
  (because t is proportional to tau for this line element). See the
  accompanying file wormhole-correct.nb for the full, correct calculation. *)
L = Sqrt[1 - D[r[t], t]^2 - (1 + r[t]^2) D[phi[t], t]^2]
eq1 = -D[D[L, r'[t]], t] + D[L, r[t]] ;
eq2 = -D[D[L, phi'[t]], t] + D[L, phi[t]] ;
sol = NDSolve[{eq1 == 0, eq2 == 0, r[0] == 2, r'[0] == -0.5, phi[0] == Pi / 4, phi'[0] == 0.099},
  {r, phi}, {t, 0, 20}, SolveDelayed → True]
Plot[r[t] /. sol[[1]], {t, 0, 20}]
g1 = ParametricPlot3D[Evaluate[
    {Sqrt[r[t]^2 + 1] Cos[phi[t]], Sqrt[r[t]^2 + 1] Sin[phi[t]], ArcSinh[r[t]]} /. sol[[1]]],
   {t, 0, 20}, AspectRatio → 1, PlotRange → All, PlotStyle → Thickness[0.01]];
g2 = ParametricPlot3D[{Sqrt[(1 + r^2)] Cos[p], Sqrt[(1 + r^2)] Sin[p], ArcSinh[r]},
   {r, -4, 4}, {p, 0, 2 Pi}];
Show[
 g1,
 g2]
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$$\sqrt{1-\left(1+r[t]^2\right) phi'[t]^2 - r'[t]^2}$$

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{{r → InterpolatingFunction[{{0., 20.}}, <>], phi → InterpolatingFunction[{{0., 20.}}, <>]}}
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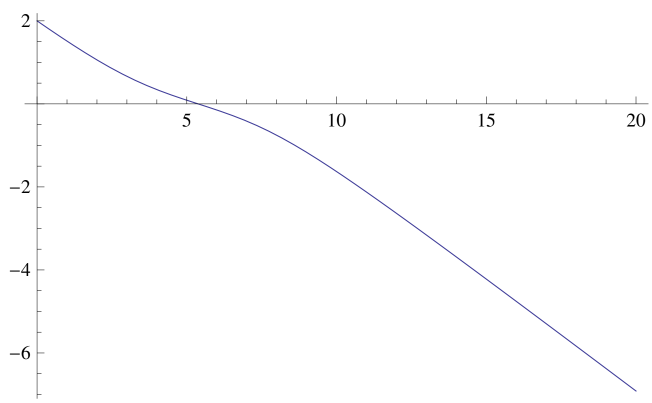

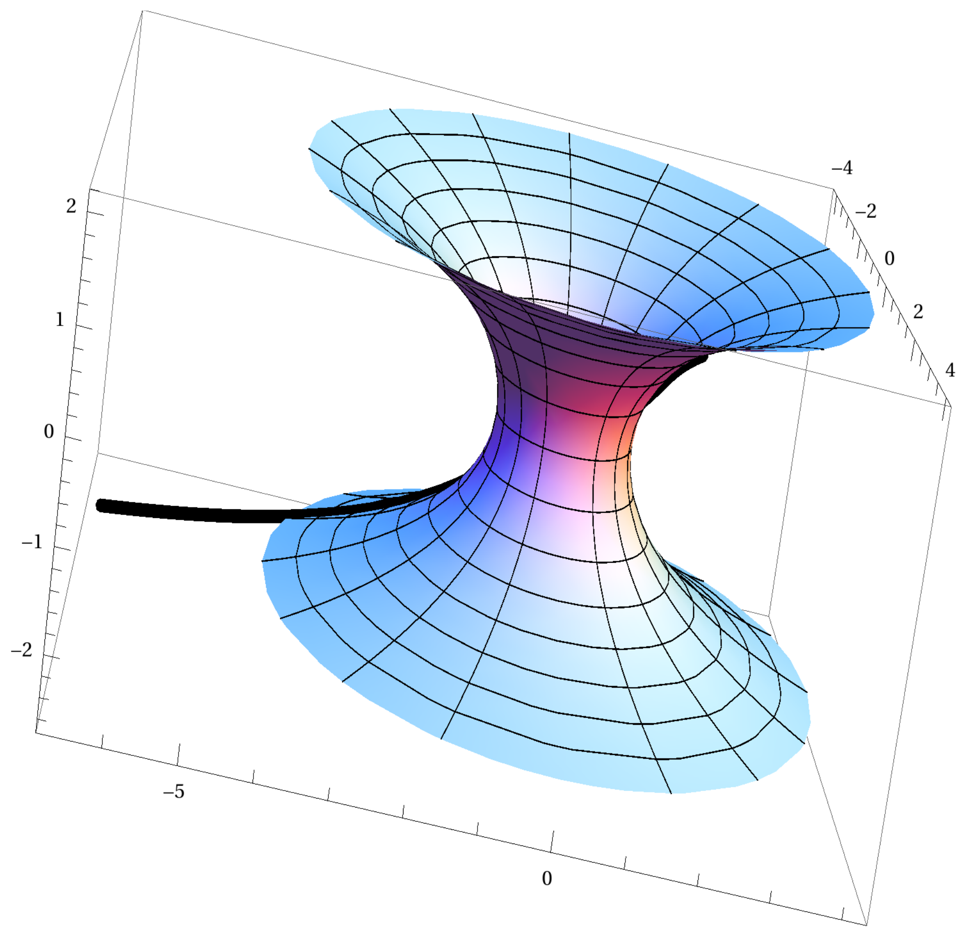

-4
-2
0
2
4
2
1
0
-1
-2
-5
0