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function [  ] = Stellar_Collapse(  )
%Written by Elmer G. Wiens December 2018
%Stellar Collapse
%Kruskal-Szekeres Coordinates
figure(1)
hold on
sq = 4;
%steps = 50;
steps = 100;
line([-sq sq], [0 0], 'Color','black','LineWidth',2)
line([0 0], [-sq, sq], 'Color','black','LineWidth',2)
line([-sq sq], [sq, sq], 'Color','black','LineWidth',2)
line([-sq sq], [-sq sq], 'Color','blue','LineWidth',3)
line([-sq sq], [sq -sq], 'Color','blue','LineWidth',3)
axis([-sq sq -sq sq])
xlabel('U', 'FontSize',17)
ylabel('V', 'FontSize',17)
title({'','Figure 1','Stationary observers at radial distances r = 2.2M, 2.5M, 3M, 3.5M',...
   ' Radial freefall of a particle from rest at rinf = 5',' Intersects observers at observers'...
   ' coordinate time t = 0'}, 'FontSize',15)
Uc = linspace(-sq, sq, steps);
for i = 1:length(Uc)
    Vc(i) = sqrt(Uc(i)^2 + 1);
end
plot (Uc,Vc, 'r', 'LineWidth',3)
plot (Uc,-Vc, 'r', 'LineWidth',3)

M = 1; M2 = 2*M;
Rt = 2.5;
r = [2.2 , 2.5,    3,    3.5];

tt = 12;
t = linspace(-tt,tt, steps);
for i = 1:length(r)
   num = sqrt(r(i) / M2 - 1) * exp(r(i) / (4*M));
   for j = 1:length(t)
      U(j) = num * cosh(t(j) / (4*M));
      V(j) = num * sinh(t(j) / (4*M));
   end
   plot(U, V, 'LineWidth', 3)
   Ut = num * cosh(0 / (4*M));
   Vt = num * sinh(0 / (4*M));
   plot(Ut, Vt, 'k*', 'LineWidth', 3)
end

Us = 0; Vs = 1;
plot(Us, Vs, 'k*', 'LineWidth', 2)
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text(1.35, 2, 'r = 0', 'FontSize',17)
text(-1.52, 2, 'r = 0', 'FontSize',17)
text(1.35, -2, 'r = 0', 'FontSize',17)
text(-1.52, -2, 'r = 0', 'FontSize',17)
text(-0.73, .8, 'r = 2M', 'FontSize',17)
text(-0.73, -.8, 'r = 2M', 'FontSize',17)
text(sq -.5, .1, 't = 0', 'FontSize',17)
text(-sq + .3, .1, 't = 0', 'FontSize',17)
line([sq, sq], [-sq, sq], 'Color','black','LineWidth',1)

taustar = 5.2704;
%taustar = 10;
tau = linspace(0, taustar, steps*2);

for j = 1:length(r)
   tstar = - M2 * ( (-2/3) * (r(j)/M2)^(3/2) - 2 * (r(j)/M2)^(1/2) + ...
      log(abs(( (r(j)/M2)^(1/2) + 1) / ((r(j)/M2)^(1/2) - 1 ))));
   for i = 1:length(tau)
      rtau(i) = (3/2)^(2/3) * M2^(1/3)* (taustar - tau(i))^(2/3);
      ttau(i) = tstar + M2 * ( (-2/3) * (rtau(i)/M2)^(3/2) - 2 * (rtau(i)/M2)^(1/2) + ...
         log(abs(( (rtau(i)/M2)^(1/2) + 1) / ((rtau(i)/M2)^(1/2) - 1 ))));
   end
   for i = 1:length(rtau)
      if (rtau(i) < M2)
         num = (1 - rtau(i) / M2)^(1/2) * exp(rtau(i) / (4*M));
         Uw(i) = num * sinh(ttau(i) / (4*M));
         Vw(i) = num * cosh(ttau(i) / (4*M));
      else
         num = sqrt(rtau(i) / M2 - 1) * exp(rtau(i) / (4*M));
         Uw(i) = num * cosh(ttau(i) / (4*M));
         Vw(i) = num * sinh(ttau(i) / (4*M));
      end
   end
   plot(Uw, Vw, 'k', 'LineWidth', 3)
   if (r(j) == Rt)
      plot(Uw, Vw, 'r', 'LineWidth', 3)
   end
end
set(gca,'FontSize',16)

Rt = 2.5;
Rt = 2.2;
Rt = 3.5;
tstar = - M2 * ( (-2/3) * (Rt/M2)^(3/2) - 2 * (Rt/M2)^(1/2) + ...
   log(abs(( (Rt/M2)^(1/2) + 1) / ((Rt/M2)^(1/2) - 1 ))));
for i = 1:length(tau)
   rtau(i) = (3/2)^(2/3) * M2^(1/3)* (taustar - tau(i))^(2/3);
   ttau(i) = tstar + M2 * ( (-2/3) * (rtau(i)/M2)^(3/2) - 2 * (rtau(i)/M2)^(1/2) + ...
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      log(abs(( (rtau(i)/M2)^(1/2) + 1) / ((rtau(i)/M2)^(1/2) - 1 ))));
end

figure(2)
hold on
%plot(tau, ttau, 'b:','LineWidth', 3)
plot(tau, rtau, 'r', 'LineWidth', 3)
adttau = ttau - tstar;
plot(tau, adttau, 'b', 'LineWidth', 3)
line([0 0], [min(ttau)-1 max(ttau)+2], 'Color','black','LineWidth',2)
line([0, taustar], [0 0],  'Color','black','LineWidth',2)
line([taustar, taustar], [min(adttau)-1, max(ttau)+2], 'Color','black','LineWidth',1)
axis([0  taustar min(adttau)-1 max(ttau)+2])
xlabel('\tau', 'FontSize',17)
ylabel('t, r/M', 'FontSize',18)
title({'','Figure 2','Particles''s \tau = proper time, r = radial distance : red,t = coordinate time: blue',...
'Radial freefall from rest at rinf, intersects stationary observers at coordinate time t = 0',' '},
'FontSize',15)
%tau ttau rtau
[Mr I] = min(abs(rtau-2));
line([tau(I) tau(I)], [min(adttau)-1 max(ttau)+2], 'Color','red','LineWidth',3)
line([0 taustar], [2 2], 'Color','red', 'LineWidth', 3)
line([0 taustar], [max(ttau)+2 max(ttau)+2],'Color','black','LineWidth',1)
%ttau(1) tstar ttau(2*steps)
set(gca,'FontSize',16)

return
end
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