```
> ###  Prof.R. Gilmore  Quantum Mechanics 1:
> ###  Constructs the normalized hydrogen radial wavefunctions
> ###  Under (int(RX(n,l,r)*R(n,l,r)*r^2,r=0..infinity)=1
> ###  Plots of radial wavefunctions.  Note how scales change!
>
>
>
> restart;
> with(orthopoly); with(plots);  ###  calls in useful orthog polys, like
  the Laguerres
```

$$[G, H, L, P, T, U]$$

```
Warning, the name changecoords has been redefined
```

[*animate*, *animate3d*, *animatecurve*, *arrow*, *changecoords*, *complexplot*, *complexplot3d*, *conformal*, *conformal3d*, *contourplot*, *contourplot3d*, *coordplot*, *coordplot3d*, *cylinderplot*, *densityplot*, *display*, *display3d*, *fieldplot*, *fieldplot3d*, *gradplot*, *gradplot3d*, *graphplot3d*, *implicitplot*, *implicitplot3d*, *inequal*, *interactive*, *listcontplot*, *listcontplot3d*, *listdensityplot*, *listplot*, *listplot3d*, *loglogplot*, *logplot*, *matrixplot*, *odeplot*, *pareto*, *plotcompare*, *pointplot*, *pointplot3d*, *polarplot*, *polygonplot*, *polygonplot3d*, *polyhedra_supported*, *polyhedraplot*, *replot*, *rootlocus*, *semilogplot*, *setoptions*, *setoptions3d*, *spacecurve*, *sparsematrixplot*, *sphereplot*, *surfdata*, *textplot*, *textplot3d*, *tubeplot*]

```
> L(5,x);              ###  for example, it works
```

$$1 - 5\,x + 5\,x^2 - \frac{5}{3}x^3 + \frac{5}{24}x^4 - \frac{1}{120}x^5$$

```
> g(5,0,x):=L(5,x);  ###  begins process for computing Associated Laguerrs
  polys
```

$$g(5, 0, x) := 1 - 5\,x + 5\,x^2 - \frac{5}{3}x^3 + \frac{5}{24}x^4 - \frac{1}{120}x^5$$

```
> for i from 1 to 7 do
  g(5,i,x):=diff(g(5,i-1,x),x):print(5,i-1,g(5,i-1,x)):od:    #(it works)
```

$$5, 0, 1 - 5\,x + 5\,x^2 - \frac{5}{3}x^3 + \frac{5}{24}x^4 - \frac{1}{120}x^5$$

$$5, 1, -5 + 10\,x - 5\,x^2 + \frac{5}{6}x^3 - \frac{1}{24}x^4$$

$$5, 2, 10 - 10\,x + \frac{5}{2}x^2 - \frac{1}{6}x^3$$

$$5, 3, -10 + 5\,x - \frac{1}{2}x^2$$

$$5, 4, 5 - x$$

$$5, 5, -1$$

$$5, 6, 0$$

```
> for j from 0 to 12 do g(j,0,x):=L(j,x);for i from 1 to j+2 do
  g(j,i,x):=diff(g(j,i-1,x),x):od:od:##  Lots of assoc lag.
```

```
> for n from 1 to 5 do for l from 0 to n-1 do R(n,l,x):=
  g(n+l,2*l+1,x)*exp(-x/2)*(x)^l:RR(n,l,r):=subs(x=2*r/n,%):N(n,l):=int(r^
  2*RR(n,l,r)^2,r=0..infinity):RX(n,l,r):=RR(n,l,r)/sqrt(N(n,l));print(n,l
  ,RX(n,l,r)):od:od:   ### constructs normalized hydrogenic radial
  wavefunctions
```

$$1,\ 0,\ -2\,\mathbf{e}^{(-r)}$$

$$2,\ 0,\ \frac{1}{4}(-2+r)\,\mathbf{e}^{\left(-\frac{1}{2}r\right)}\sqrt{2}$$

$$2,\ 1,\ -\frac{1}{12}\,\mathbf{e}^{\left(-\frac{1}{2}r\right)}\,r\sqrt{6}$$

$$3,\ 0,\ \frac{2}{27}\left(-3+2\,r-\frac{2}{9}r^2\right)\mathbf{e}^{\left(-\frac{1}{3}r\right)}\sqrt{3}$$

$$3,\ 1,\ \frac{1}{81}\left(-4+\frac{2}{3}r\right)\mathbf{e}^{\left(-\frac{1}{3}r\right)}\,r\sqrt{6}$$

$$3,\ 2,\ -\frac{2}{1215}\,\mathbf{e}^{\left(-\frac{1}{3}r\right)}\,r^2\sqrt{30}$$

$$4,\ 0,\ \frac{1}{16}\left(-4+3\,r-\frac{1}{2}r^2+\frac{1}{48}r^3\right)\mathbf{e}^{\left(-\frac{1}{4}r\right)}$$

$$4,\ 1,\ \frac{1}{480}\left(-10+\frac{5}{2}r-\frac{1}{8}r^2\right)\mathbf{e}^{\left(-\frac{1}{4}r\right)}\,r\sqrt{15}$$

$$4,\ 2,\ \frac{1}{1920}\left(-6+\frac{1}{2}r\right)\mathbf{e}^{\left(-\frac{1}{4}r\right)}\,r^2\sqrt{5}$$

$$4,\ 3,\ -\frac{1}{26880}\,\mathbf{e}^{\left(-\frac{1}{4}r\right)}\,r^3\sqrt{35}$$

$$5, 0, \frac{2}{125}\left(-5 + 4\,r - \frac{4}{5}r^2 + \frac{4}{75}r^3 - \frac{2}{1875}r^4\right)\mathbf{e}^{\left(-\frac{1}{5}r\right)}\sqrt{5}$$

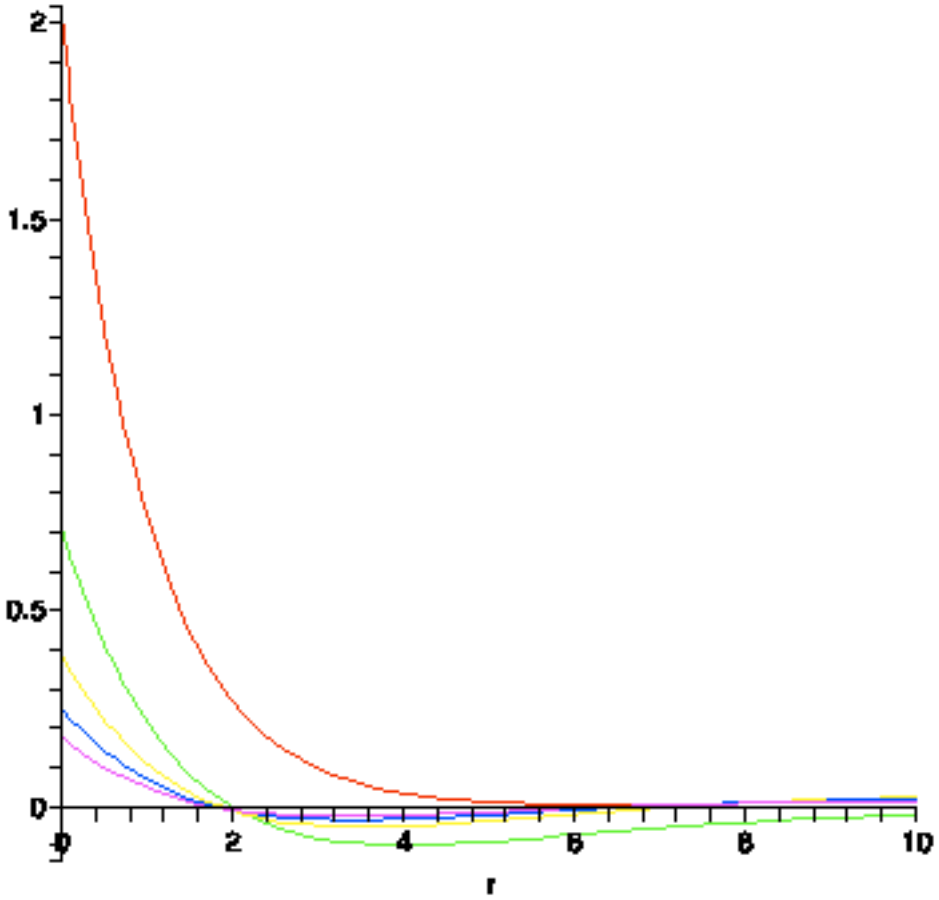
$$5, 1, \frac{1}{1875}\left(-20 + 6\,r - \frac{12}{25}r^2 + \frac{4}{375}r^3\right)\mathbf{e}^{\left(-\frac{1}{5}r\right)}r\sqrt{30}$$

$$5, 2, \frac{2}{65625}\left(-21 + \frac{14}{5}r - \frac{2}{25}r^2\right)\mathbf{e}^{\left(-\frac{1}{5}r\right)}r^2\sqrt{70}$$

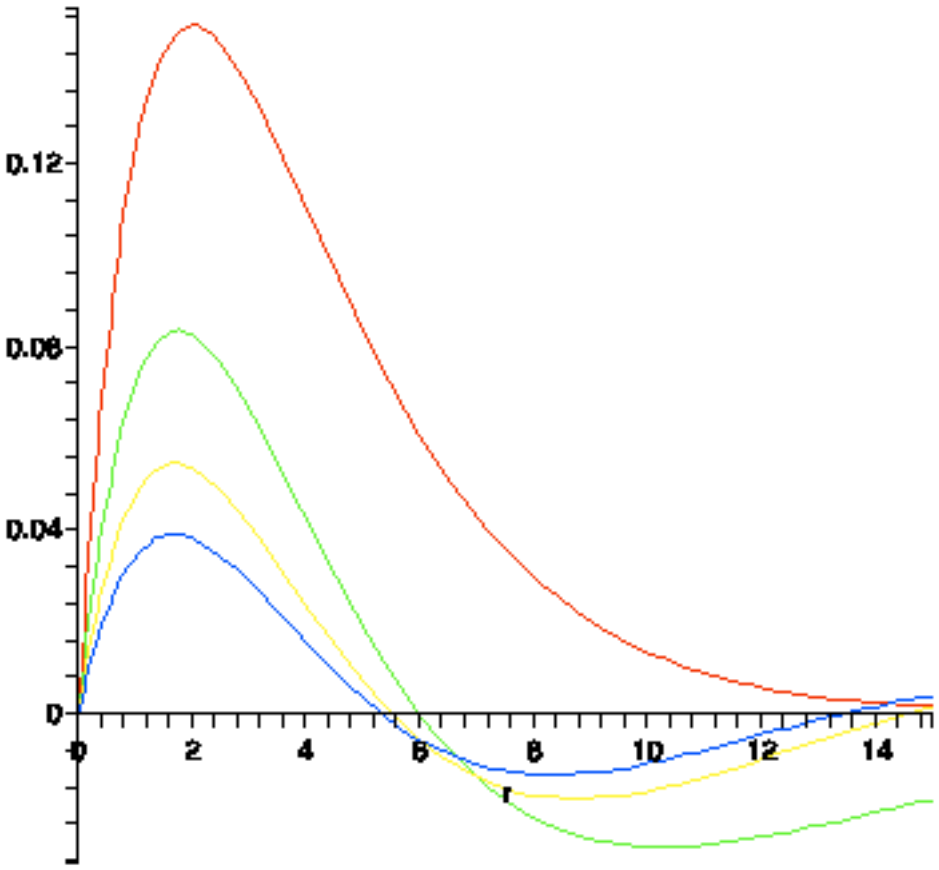
$$5, 3, \frac{1}{328125}\left(-8 + \frac{2}{5}r\right)\mathbf{e}^{\left(-\frac{1}{5}r\right)}r^3\sqrt{70}$$

$$5, 4, -\frac{2}{4921875}\mathbf{e}^{\left(-\frac{1}{5}r\right)}r^4\sqrt{70}$$

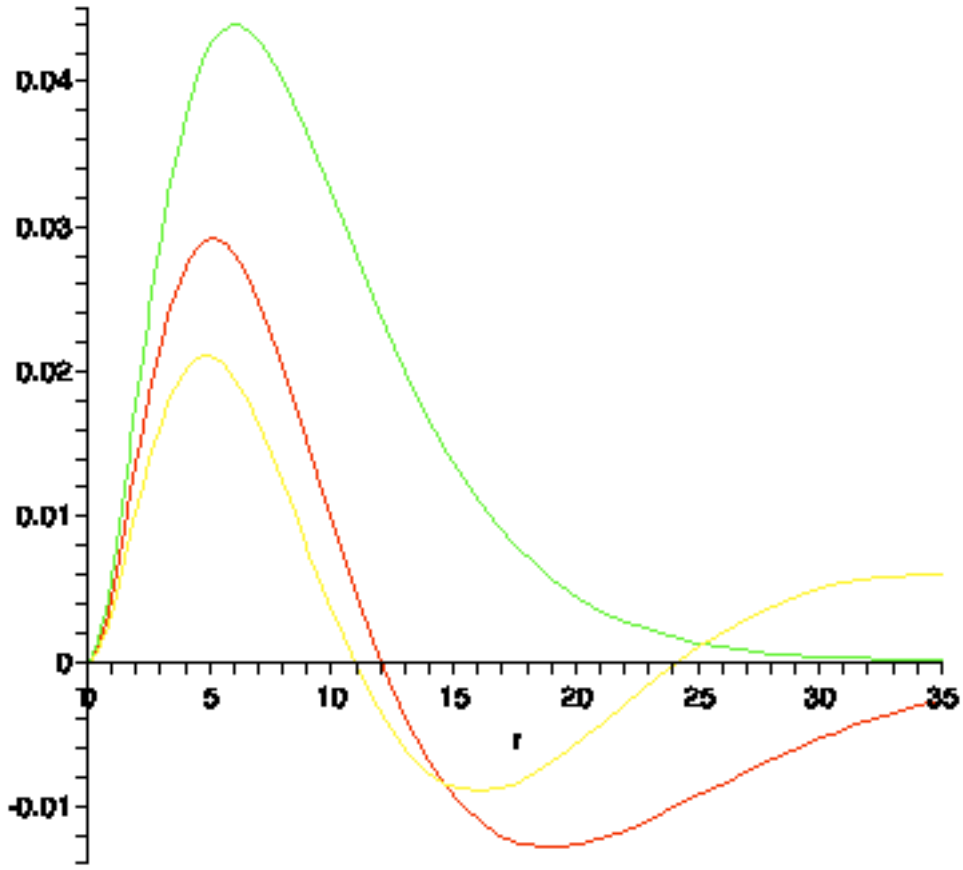
```
> plot({-RX(1,0,r),-RX(2,0,r),-RX(3,0,r),-RX(4,0,r),-RX(5,0,r)},r=0..10);
   ###  s states
```



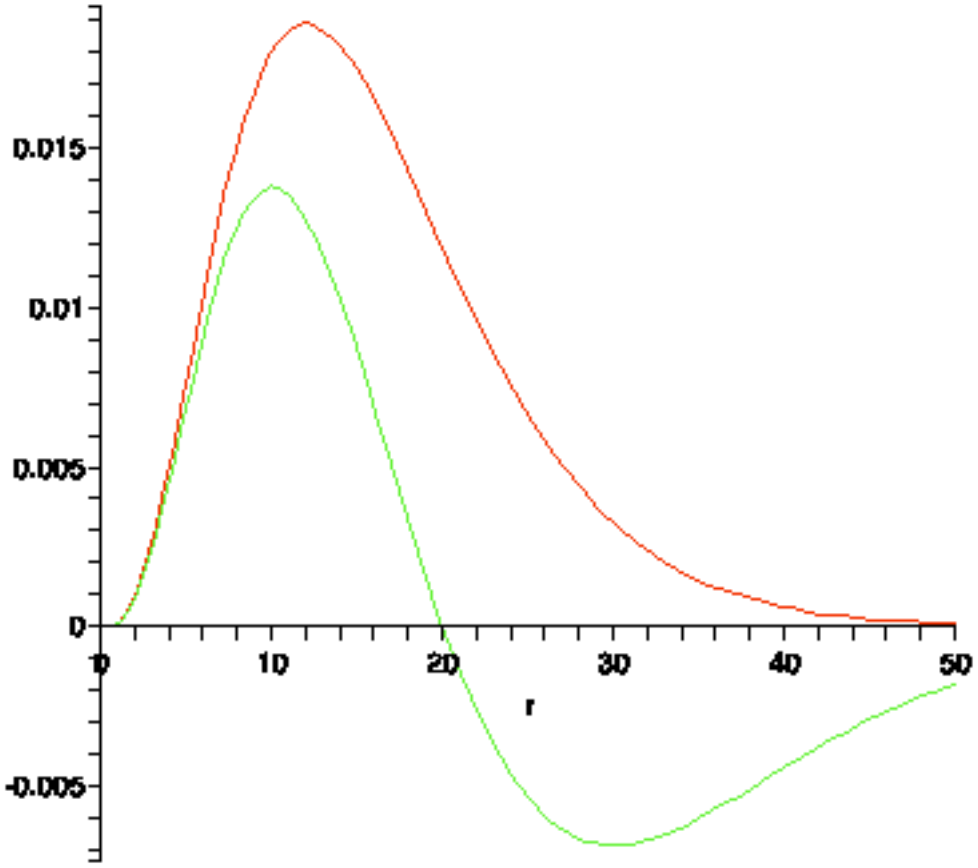

```
> plot({-RX(2,1,r),-RX(3,1,r),-RX(4,1,r),-RX(5,1,r)},r=0..15);    ### p
  states
```



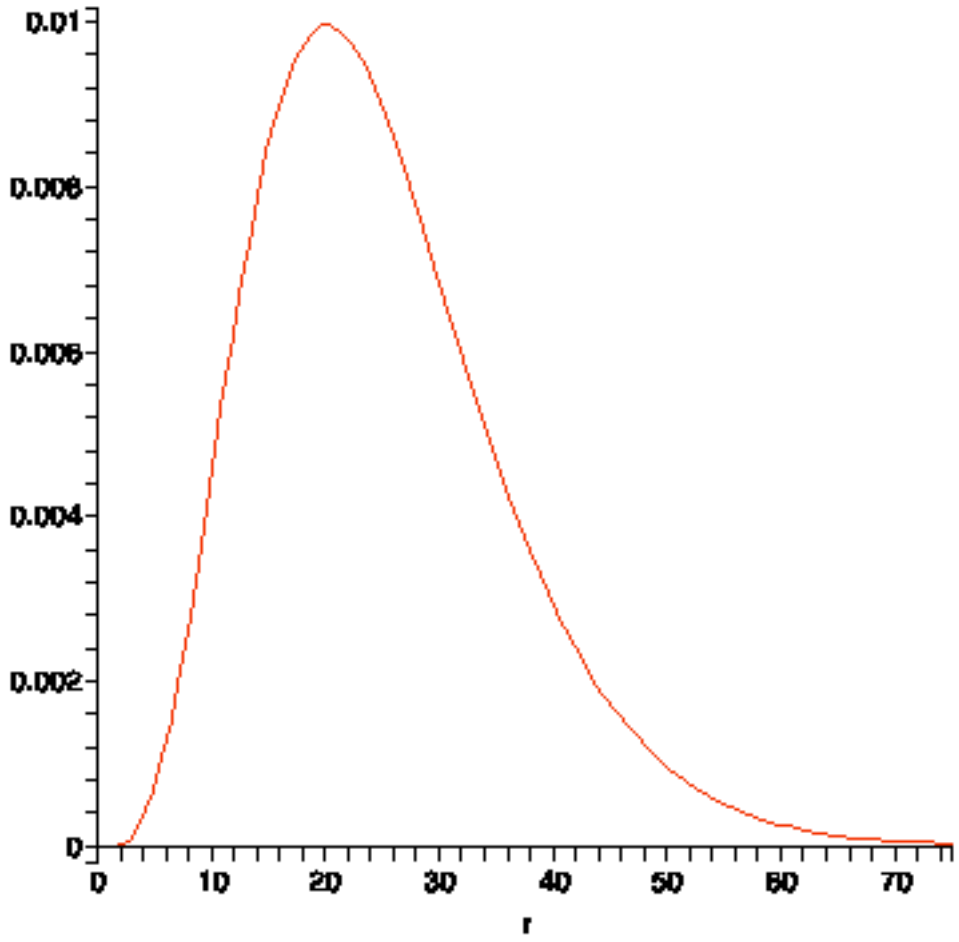

```
> plot({-RX(3,2,r),-RX(4,2,r),-RX(5,2,r)},r=0..35);   ### d states
```



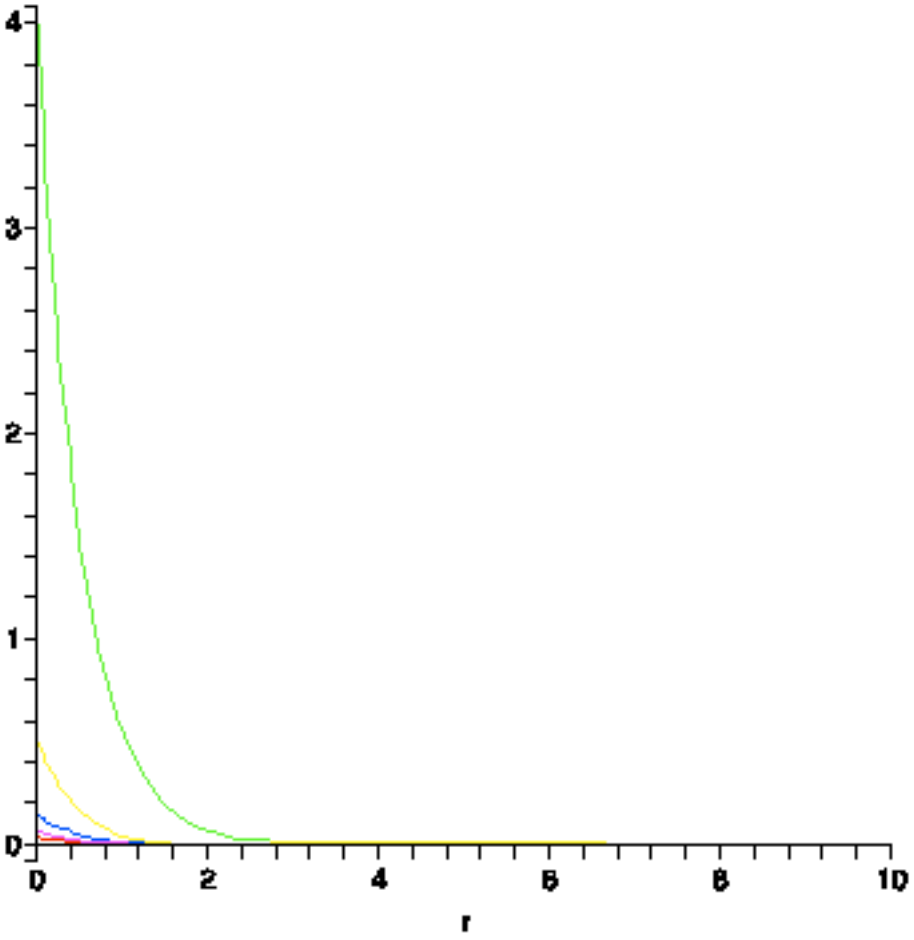

```
> plot({-RX(4,3,r),-RX(5,3,r)},r=0..50);    ### f states
```



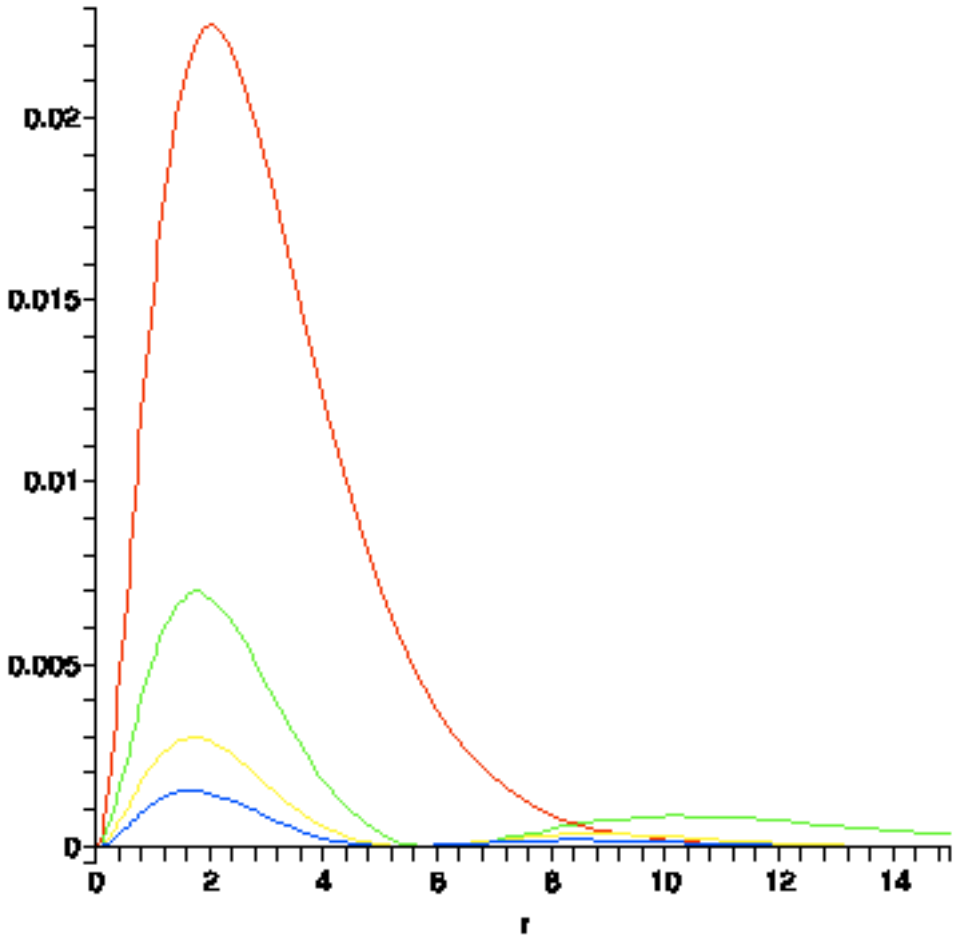

```
> plot({-RX(5,4,r)},r=0..75);   ### g states
```



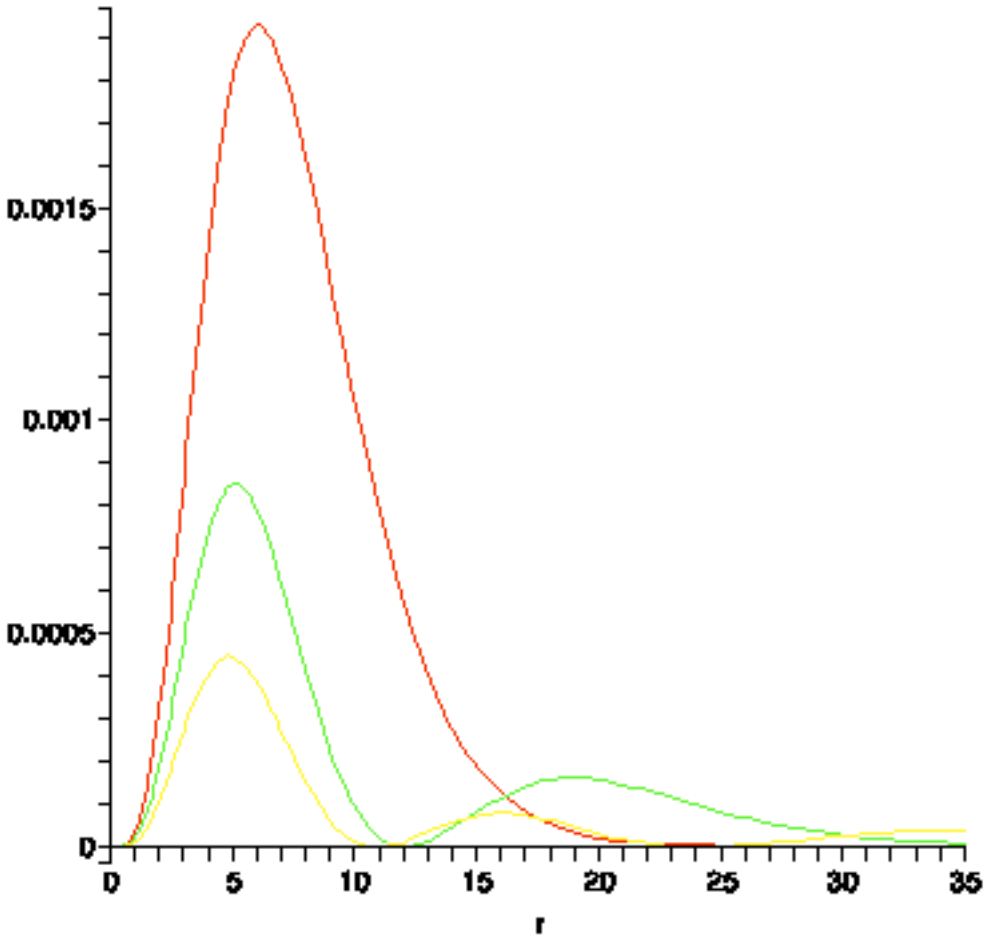

```
> plot({RX(1,0,r)^2,RX(2,0,r)^2,RX(3,0,r)^2,RX(4,0,r)^2,RX(5,0,r)^2},r=0..
  10);   ###  s states
```



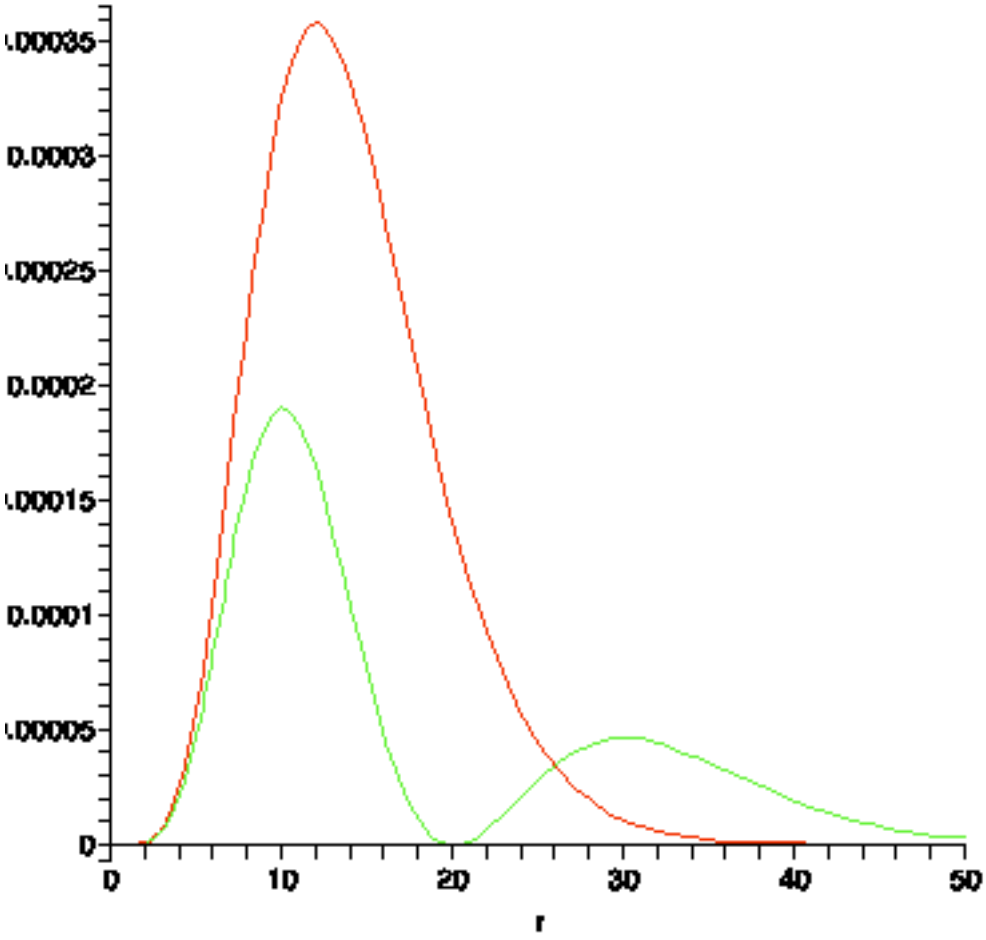

```
> plot({RX(2,1,r)^2,RX(3,1,r)^2,RX(4,1,r)^2,RX(5,1,r)^2},r=0..15);    ### p
  states
```



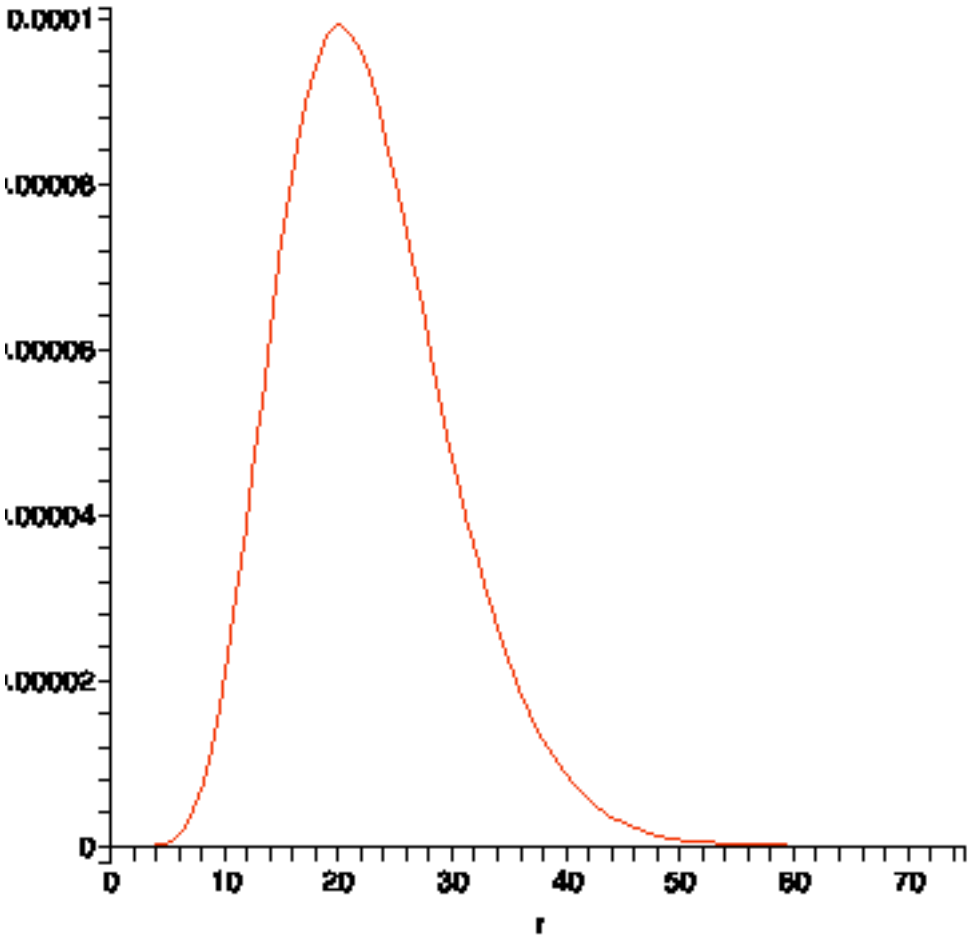

```
> plot({RX(3,2,r)^2,RX(4,2,r)^2,RX(5,2,r)^2},r=0..35);   ### d states
```




```
> plot({RX(4,3,r)^2,RX(5,3,r)^2},r=0..50);   ### f states
```




```
> plot({RX(5,4,r)^2},r=0..75);   ### g states
```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.00002
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