```
In[•]:= ClearAll["Global`*"]
        borra todo
```

Funciones radiales

```
In[•]:= R10[r_, Z_] := 2 (Z)^(3/2) Exp[-Z r];
                       exponencial

        R21[r_, Z_] := 1/Sqrt[3] (Z/2)^(3/2) (Z r) Exp[(-Z r)/2];
                                                   exponencial

        R20[r_, Z_] := 2 (Z/2)^(3/2) (1 - (Z r)/2) Exp[(-Z r)/2];
                                                   exponencial
```

Integral de Coulomb

```
In[•]:= CoulombIntegral[r1_, r2_, Z_, n_, l_] :=
          Integrate[r2^2 * If[n == 2 && l == 0, R20[r2, Z]^2, R21[r2, Z]^2] *
          integra  si

            (Integrate[1/r2 r1^2 (R10[r1, Z])^2, {r1, 0, r2}]
            integra

              + Integrate[1/r1 r1^2 (R10[r1, Z])^2, {r1, r2, ∞}]),
                integra

          {r2, 0, ∞}];
```

Integral de intercambio

```
In[•]:= ExchangeIntegral[r1_, r2_, Z_, n_, l_] :=
  1/(2 l + 1) * Integrate[r2^2 R10[r2, Z] * If[n == 2 && l == 0, R20[r2, Z], R21[r2, Z]] *
    (Integrate[r1^2 R10[r1, Z] * If[n == 2 && l == 0, R20[r1, Z], R21[r1, Z]] (r1)^l/(r2)^(l+1),
      {r1, 0, r2}] + Integrate[
      r1^2 R10[r1, Z] * If[n == 2 && l == 0, R20[r1, Z], R21[r1, Z]] (r2)^l/(r1)^(l+1), {r1, r2, ∞}]),
   {r2, 0, ∞}]
```

Integrales para n = 2 y l = 1

```
In[•]:= J20 = CoulombIntegral[r, ρ, 2, 2, 0]
```

Out[•]=

$$\frac{34}{81}$$

```
In[•]:= K20 = ExchangeIntegral[r, ρ, 2, 2, 0]
```

Out[•]=

$$\frac{32}{729}$$

Integrales para n = 2 y l = 2

```
In[•]:= J21 = CoulombIntegral[r, ρ, 2, 2, 1]
```

Out[•]=

$$\frac{118}{243}$$

```
In[•]:= K21 = ExchangeIntegral[r, ρ, 2, 2, 1]
```

Out[•]=

$$\frac{224}{6561}$$

Energía a primer orden de aproximación

Estados 2^1S y 2^3S

```
In[•]:= FirstOrderCorrectionNL[J_, K_] := J ± K;
```

```
In[•]:= FirstOrderCorrection20 = FirstOrderCorrectionNL[J20, K20]
```

```
Out[•]=
```

$$\frac{34}{81} \pm \frac{32}{729}$$

Estados 2^1P y 2^3P

```
In[•]:= FirstOrderCorrection21 = FirstOrderCorrectionNL[J21, K21]
```

```
Out[•]=
```

$$\frac{118}{243} \pm \frac{224}{6561}$$

Energía imperturbada

```
In[•]:= UnperturbedEnergyN[Z_, n_] := -Z^2/2 (1 + 1/n^2);
```

```
In[•]:= UnperturbedEnergy2 = UnperturbedEnergyN[2, 2]
```

```
Out[•]=
```

$$-\frac{5}{2}$$

Energía

Energía para estados 2^1S y 2^3S

```
In[•]:= UnperturbedEnergy2 + FirstOrderCorrection20
```

```
Out[•]=
```

$$-\frac{5}{2} + \left(\frac{34}{81} \pm \frac{32}{729}\right)$$

Energía para estados 2^1P y 2^3P

```
In[•]:= UnperturbedEnergy2 + FirstOrderCorrection21
```

```
Out[•]=
```

$$-\frac{5}{2} + \left(\frac{118}{243} \pm \frac{224}{6561}\right)$$