```
(%i1) kill(all);
(%o0) done
```

1 Solve eqs.(16,17)

```
(%i1) E16: v[r,P] = (1+Omega[101])*v[r,N]+Omega[102]*v[theta,N];
      E17: v[theta,P] = (1+Omega[202])*v[theta,N]+Omega[201]*v[r,N];
```

$$(\%o1)\quad v_{r,P}=\Omega_{102}\,v_{\theta,N}+(\Omega_{101}+1)\,v_{r,N}$$

$$(\%o2)\quad v_{\theta,P}=(\Omega_{202}+1)\,v_{\theta,N}+\Omega_{201}\,v_{r,N}$$

```
(%i3) solve([E16, E17], [v[r,N], v[theta,N]]);
```

$$(\%o3)\quad \left[\left[v_{r,N}=-\frac{(\Omega_{202}+1)\,v_{r,P}-\Omega_{102}\,v_{\theta,P}}{-\Omega_{202}+\Omega_{101}\,(-\Omega_{202}-1)+\Omega_{102}\,\Omega_{201}-1},\ v_{\theta,N}=\frac{-\Omega_{101}\,v_{\theta,P}-v_{\theta,P}+\Omega_{201}\,v_{r,P}}{-\Omega_{202}+\Omega_{101}\,(-\Omega_{202}-1)+\Omega_{102}\,\Omega_{201}-1}\right]\right]$$

```
(%i4) S: ratsimp(%);
```

$$(\%o4)\quad \left[\left[v_{r,N}=-\frac{\Omega_{102}\,v_{\theta,P}+(-\Omega_{202}-1)\,v_{r,P}}{(\Omega_{101}+1)\,\Omega_{202}-\Omega_{102}\,\Omega_{201}+\Omega_{101}+1},\ v_{\theta,N}=\frac{(\Omega_{101}+1)\,v_{\theta,P}-\Omega_{201}\,v_{r,P}}{(\Omega_{101}+1)\,\Omega_{202}-\Omega_{102}\,\Omega_{201}+\Omega_{101}+1}\right]\right]$$

2 Approximations

```
(%i5) Omega[102]: Omega[201]: 0;
(%o5) 0
```

```
(%i6) S1: factor(ev(S));
```

$$(\%o6)\quad \left[\left[v_{r,N}=\frac{v_{r,P}}{\Omega_{101}+1},\ v_{\theta,N}=\frac{v_{\theta,P}}{\Omega_{202}+1}\right]\right]$$

2.1 Solving for the spin connections

```
(%i7) S2: expand(solve(first(S), [Omega[101],Omega[202]]));
```

$$(\%o7)\quad \left[\left[\Omega_{101}=\frac{v_{r,P}}{v_{r,N}}-1,\ \Omega_{202}=\frac{v_{\theta,P}}{v_{\theta,N}}-1\right]\right]$$

2.2 Inserting ratio of velocities

```
(%i8) v[r,P]: omega*'diff(r[P],theta);
      v[theta,P]: omega*r[P];
```

(%o8) $\omega\left(\frac{d}{d\,\theta}\,r_P\right)$

(%o9) $\omega\,r_P$

```
(%i10) v[r,N]: omega*'diff(r[N],theta);
       v[theta,N]: omega*r[N];
```

(%o10) $\omega\left(\frac{d}{d\,\theta}\,r_N\right)$

(%o11) $\omega\,r_N$

```
(%i12) S3: ev(S2);
```

(%o12) $$\left[\left[\Omega_{101}=\frac{\frac{d}{d\,\theta}\,r_P}{\frac{d}{d\,\theta}\,r_N}-1,\Omega_{202}=\frac{r_P}{r_N}-1\right]\right]$$

Inserting precessing orbit

```
(%i13) r[N]: alpha/(1+epsilon*cos(theta));
```

(%o13) $$\frac{\alpha}{\varepsilon\,\cos(\theta)+1}$$

```
(%i14) r[P]: alpha/(1+epsilon*cos(x*theta));
```

(%o14) $$\frac{\alpha}{\varepsilon\,\cos(\theta\,x)+1}$$

```
(%i15) S4: ev(S3,diff);
```

(%o15) $$\left[\left[\Omega_{101}=\frac{(\varepsilon\,\cos(\theta)+1)^2\,x\,\sin(\theta\,x)}{\sin(\theta)\,(\varepsilon\,\cos(\theta\,x)+1)^2}-1,\Omega_{202}=\frac{\varepsilon\,\cos(\theta)+1}{\varepsilon\,\cos(\theta\,x)+1}-1\right]\right]$$

Further approximations

```
(%i16) ev(S4, [cos(x*theta)=cos(theta),sin(x*theta)=sin(theta)]);
```

(%o16) $\left[\left[\Omega_{101}=x-1,\Omega_{202}=0\right]\right]$

```
(%i17) ev(S4, [cos(x*theta)=cos(theta),sin(x*theta)=x*(theta),sin(theta)=
```

(%o17) $\left[\left[\Omega_{101}=x^2-1,\Omega_{202}=0\right]\right]$