

treeamps4dJAF: A MATHEMATICA PACKAGE FOR SOLVING THE 4D SCATTERING EQUATIONS

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Based on J. A. Farrow, "A Monte Carlo Approach to the 4D Scattering Equations", 1806.02732

THE 4D SCATTERING EQUATIONS



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$$|l\rangle = \sum_{r \in R} \frac{|r\rangle}{\sigma_l^1 \sigma_r^2 - \sigma_l^2 \sigma_r^1} \quad |r\rangle = \sum_{l \in L} \frac{|l\rangle}{\sigma_l^1 \sigma_r^2 - \sigma_l^2 \sigma_r^1}$$

THE 4D SCATTERING EQUATIONS



$$|l\rangle = \sum_{r \in R} \frac{|r\rangle}{\sigma_l^1 \sigma_r^2 - \sigma_l^2 \sigma_r^1} \quad |r\rangle = \sum_{l \in L} \frac{|l\rangle}{\sigma_l^1 \sigma_r^2 - \sigma_l^2 \sigma_r^1}$$

$$\mathcal{A}_{n,L} = \sum_{\sigma_{\text{sol}} \in \text{solutions}} f(\sigma_{\text{sol}})$$

SOLVING THE EQUATIONS



n	# solutions
4	1
5	1 1
6	1 4 1
7	1 11 11 1
8	1 26 66 26 1

SOLVING THE EQUATIONS



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4	1
5	1 1
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Find with a Monte-Carlo algorithm



```
In[1]:= <<treeamps4dJAF`;
```



```
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```

```
In[2]:= mom = RandomMomenta4D[6];
```




```
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```

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In[2]:= mom = RandomMomenta4D[6];
```

```
In[3]:= Amplitude["YM", 4, mom, "g-", {"φ", 1, 2},  
{"φ", 3, 4}, "g+", {"ψ-", 1, 2, 3}, {"ψ+", 4}]
```



```
In[1]:= <<treeamps4dJAF`;
```

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In[2]:= mom = RandomMomenta4D[6];
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In[3]:= Amplitude["YM", 4, mom, "g-", {"φ",1,2},  
{"φ",3,4}, "g+", {"ψ-",1,2,3}, {"ψ+",4}]
```

```
Out[3]= 11.8556 - 30.6627 I
```



```
In[4]:= Amplitude["EG", 4, "h-", "h+", "φ-", "φ+"]
```



```
In[4] := Amplitude["EG", 4, "h-", "h+", "φ-", "φ+"]
```

```
Out[4] = 
$$\frac{\text{ang}[1,3]^2 \text{ang}[1,4]^3 \text{squ}[2,4]}{\text{ang}[1,2] \text{ang}[2,3] \text{ang}[2,4] \text{ang}[3,4]}$$

```



```
In[4]:= Amplitude["EG", 4, "h-", "h+", "φ-", "φ+"]
```

```
Out[4]= 
$$\frac{\text{ang}[1,3]^2 \text{ang}[1,4]^3 \text{squ}[2,4]}{\text{ang}[1,2] \text{ang}[2,3] \text{ang}[2,4] \text{ang}[3,4]}$$

```

```
In[5]:= % // AmplitudesDisplay
```



```
In[4]:= Amplitude["EG", 4, "h-", "h+", "φ-", "φ+"]
```

$$\text{Out}[4]= \frac{\text{ang}[1,3]^2 \text{ang}[1,4]^3 \text{squ}[2,4]}{\text{ang}[1,2] \text{ang}[2,3] \text{ang}[2,4] \text{ang}[3,4]}$$

```
In[5]:= % // AmplitudesDisplay
```

$$\text{Out}[5]= \frac{\langle 13 \rangle^2 \langle 14 \rangle^3 [24]}{\langle 12 \rangle \langle 23 \rangle \langle 24 \rangle \langle 34 \rangle}$$



Thank you for listening!

References:

F. Cachazo, S. He, and E. Y. Yuan, "Scattering of Massless Particles in Arbitrary Dimensions", 1307.2199.

Y. Geyer, A. E. Lipstein, and L. J. Mason, "Ambitwistor Strings in Four Dimensions", 1404.6219

J. A. Farrow, "A Monte Carlo Approach to the 4D Scattering Equations", 1806.02732