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Tzór

Theorized package of sum rules

Poplar *

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An Awesome Publisher

* A LaTeX lover

The *Tzór* class

Disclaimer

Tzór 是一个为QCD求和规则设计的Mathematica程序包。它虽然还欠缺许多功能，但已经足够强大到可以处理在QCD求和规则计算中遇到的绝大多数问题。

Colophon

Tzór 手册采用的是基于KOMA-Script 和 LaTeX编写的kaobook LaTeX代码。
你可以在这里
`https://github.com/fmarotta/kaobook`找到它们。

Publisher

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One can call Tyre a city of ruins, built out of ruins.
我们可以说推罗是废墟之城，它由废墟建成。

– Ernest Renan 恩斯特·雷南

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1.1 为什么是Tzór

推罗(Tzór)是黎巴嫩的一个城市，现基督教世界一般称之为提尔（Tyre），伊斯兰世界称之为苏尔（Ṣūr）。Tzór是其希伯来语称呼。除此之外阿卡德人称之为Ṣurru，腓尼基人称之为Ṣūr，希腊人称之为Týros。并因此衍化成拉丁语的Tyrus以及英语中的Tyre。在公元前2750年，推罗便已建立，事实上推罗是最为古老的连续有人居住的城市之一。

推罗的建城有许多传说。其中最为普遍的一个是即神梅尔卡特·赫拉克勒斯（Melqart Heracles）建造这座城市是为了吸引宁芙仙女蒂洛（Tyros），并以她的名字命名。因此梅尔卡特被推罗奉为自己的守护神。另有一说，推罗的建城者乌索斯（Usoos），利用一根树干在海面上航行。这根树干也成为第一艘船只。航行到一个小岛并在此建立了名为Ushu的推罗。在希腊神话中，宙斯绑架至克里特岛的公主欧罗巴即来自于推罗。而随之寻找公主的推罗王子们也给希腊人带来文字。

随后，推罗处于埃及法老们的统治之下。在此期间，推罗人已经建立了一种稀有且昂贵的紫色染料工业，即泰利安紫（Tyrian purple）或称皇家紫色（Royal purple）。据说推罗的守护神梅尔卡特·赫拉克勒斯与宁芙仙女蒂洛在海边散步时，他的狗咬到一种软体蜗牛，将自己的嘴唇染成了紫色。蒂洛希望得到一件颜色与此相同的染色连衣裙。从而泰利安紫便诞生了。而这一地区的人也被希腊人称之为“紫色的人”（Phoenicia），即腓尼基人。据记载在此期间推罗的一些水手便已到达不列颠岛，并在此购买锡打造武器。希德罗德在《历史》中记载，埃及的法老曾经雇佣过一支腓尼基水手，从红海出发完成了人类历史上首次环非洲大陆的航行。

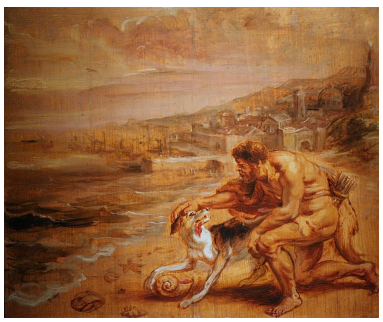


Figure 1.1: 紫色的发现——彼得·保罗·鲁本斯

随着埃及势力的衰退，腓尼基推罗也随之独立。腓尼基人逐步建立起东地中海的贸易霸权。甚至于地中海被称之为泰利安海。推罗的公主狄多（Dido）女王在政治斗争失利被流放后，来到突尼斯。并在此建立了之后威震西地中海的迦太基城。前325年，几何之父欧几里得（Euclid）便出生于推罗。

推罗是骄傲的，它的骄傲使得上帝本人产生妒忌。因此，上帝本人亲自为推罗做出预言：不断的毁灭。赫梯和亚述帝国曾多次征讨推罗。并最终在前631年被亚述巴尼拔（Asurbanipal）彻底摧毁。但不久推罗又恢复往日繁华。随着亚述的衰败，巴比伦王国的崛起。

巴比伦王尼布甲尼撒二世（Nebuchadnezzar II）在前586年展开了对推罗长达13年的围城，并最终使推罗臣服。
巴比伦陷落后，阿契美尼德波斯的居鲁士大帝（Cyrus the Great）于前539年再次征服推罗。前392年，推罗人秘密同意塞浦路斯王子埃瓦戈拉斯（Evagoras）夺走推罗，波斯人再次对推罗征伐，并在十年后平定了这场叛乱。
前333年亚历山大大帝（Alexander the Great）击败波斯皇帝大流士三世（Darius III），地中海沿岸的腓尼基城邦纷纷开城迎接，除了推罗。推罗拒绝了亚历山大大帝进城祭拜赫拉克勒斯的建议。亚历山大被这种行为激怒，随之展开对推罗为期七个月的围攻。征服推罗后，亚历山大大帝将其旧城区拆除，用所得的石料建造了通向推罗岛的堤道。推罗此后便从一个岛屿变为半岛。

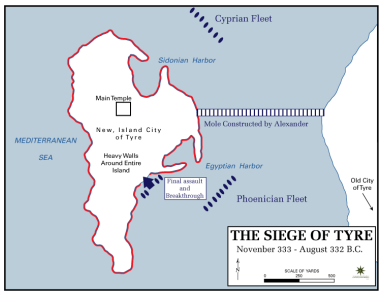


Figure 1.2: 推罗之围，以及亚历山大留下的堤道

继业者战争期间，推罗起初被埃及的托勒密一世（Ptolemy I）吞并,之后被安提柯一世（Antigonus I）围攻并征服。安提柯的继任者德米特里（Demetrius）之后将其又移交给托勒密，但后者在控制其七十年后被塞琉古帝国的安条克三世（Antiochus III）再次围攻并征服。
随着塞琉古被罗马帝国征服，推罗成为罗马叙利亚省的一部分，称为帝国的一个自由市。推罗也因罗马帝国长达二百多年的黄金时期而一度享受和平。但安乐日不可长久，随着帝国的式微，萨珊波斯、阿拉伯帝国、法蒂玛王朝、十字军、马穆鲁克都曾征服过这座古老的东地中海城市。甚至直至现在，推罗城依旧处于巴以双方的火炮射程之内。事实上，推罗在建城的近五千年间，会以大概七十年为一个周期性因地震、海啸、战争等天灾人祸而陷入毁灭-重生-繁荣-毁灭的循环之中。
推罗这种不断被毁灭却又不断重生的经历和科学研究的过程极为相似。在科学研究中，我们不断因碰到新的困难，而放弃之前的做法，陷入方法-问题-思路-方法的循环之中。但在此期间同推罗一样也能做出些许成就。基于这个想法，我们将这个程序包命名为*Tzór*。因为事实上，我们的研究工作也同推罗一样由废墟建成。
*Tzór*是一款基于 `Mathematica` 的程序包。我们将QCD求和规则中涉及到有关轻夸克的繁琐复杂计算封装进特定函数。只需要调用这些函数便可以实现QCD求和规则的相关计算。*Tzór*实现了对流算符编时乘积的Wick收缩，对各费曼图的计算以及过程中用到的各种数学变换。它的输入极为简单，只需要输入流算符便可进行计算。其次它的计算过程和人类计算习惯是类似的，以便于其能方便检验分析一些图的结果。同时它的输出结果也是简单易读的。

1.2 Tzór可以做什么

*Tzór*致力于解决轻夸克的求和规则计算，它封装的许多函数使得计算变得简单，代码变得易懂。但这也意味着，其封装的函数不一定是用户所需要的，同时用户所需要的函数也并不一定都进行了封装。因此有必要做一汇总。*Tzór*的特性如下：

费米子场 费米子场是计算的基本，因此我们提供了定义夸克场的方法。

矩阵 自然地，矩阵也是必要的输入。

传播子 传播子既可以作为输入，也可以作为一种中间过程。

wick收缩 我们提供了两种wick收缩，一种是显式矩阵元形式的，而另一种矩阵元则是隐式的。

Feynman图计算 *Tzór*的计算是以每张Feynman图为基本单元的，这意味着*Tzór*并不能区分只交换了夸克线的两幅图。不过不用担心，我们只需要算完所有可能的置换即可。这一点Mathematica和*Tzór*都封装了相应功能。

傅里叶变换 我们提供了一个d维的傅里叶变换。并在$d \to 4$时略去了其可能产生的无穷大。

Borel变换 与此同时我们也提供了一个Borel变换，尽管在许多目前的计算中，它可能不是很被需要。

爱因斯坦求和约定 爱因斯坦求和约定实际上是我们为了计算色指标收缩时开发的额外功能，当张量被显式的给出之后，利用它去计算缩并是清晰的。

信息读取 因为在封装功能的过程中，我们要不断对结果的信息进行提取。为了便于在此基础上继续开发新功能，我们将其接口保留了下来。其涉及到对颜色、自旋指标、凝聚量的读取，对是否为夸克、是否是凝聚量的判断等一系列功能。

在有了这些功能后*Tzór*便足够强大到可以计算QCD求和规则中涉及到轻夸克的所有必要计算，并且使得计算耗时保持在可以让人接受的十分钟以内。

1.3 Tzór做不了什么

当然*Tzór*目前还并不足够完美，依旧有许多功能尚没有实现：

玻色子场 目前*Tzór*尚不支持流算符中含有玻色子场的计算。当然这并不是什么难事，因为费米子场的wick收缩比玻色子反而复杂。我们将会在之后的更新中添加上它。

重夸克 重夸克同轻夸克主要体现在其动量同质量的比值上。或言重夸克是非相对论性的，而轻夸克是相对论性的。重夸克涉及到对Feynman图的积分。尽管*Tzór*有能力让函数自动写出积分的形式，但因为Mathematica太过灵活，*Tzór*没有足够的信心将之交给计算机直接去计算。因而*Tzór*并没有实现相关功能。

辐射修正 辐射修正是重要的，但因为其涉及到圈积分，出于同样的原因*Tzór*也没有去实现它。

反常量纲 事实上*Tzór*已经有足够的功能去开发反常量纲对结果的修正了，这在之后会随之更新。

一些傅里叶变换 尽管*Tzór*的傅里叶变换已经足够聪明到可以识别含有/x和没有它的输入。但其尚不能识别x_μ或着$x_\mu xv$...形式的输入，目前用户们可能仍然需要自己对其进行求导计算。不过在之后的版本里*Tzór*会使其自动化实现。

对称性 目前*Tzór*在处理对称性上使用的办法是笨拙的，也就是说两个结构对称与否*Tzór*是不关心的，它只会老实地将每个结构进行计算。显然这个过程会使得计算量飞增。

版本兼容性 在FeynCalc这个程序包版本大于等于9.3.0时，*Tzór*的示例代码可能会出错。目前尚未找到具体原因，猜测可能是因为FeynCalc移除了某些功能。为保持结果一致，推荐在Mathematica版本为11.0以上，FeynCalc为9.2.0的环境中使用。

随着之后的更新*Tzór*会随之完善增加新的功能，使得其可以胜任大多数繁琐复杂的QCD计算。

1.4 如何使用Tzór

你可以访问 *Tzór*, 或者

Tzór, 你将会得到一个名为tzor.m的Mathematica程序包和一个名为 factors.csv 的数据文件。将其复制至你的工作目录下即可。如果csv文件发生毁坏，可以新建一个同名文件。并写入：

```
1,1
```

在Mathematica中新建文件，并键入以下命令

```
Once[Get[NotebookDirectory[] <> "tzor.m"]];
```

当其显示：

```
Tzor : Theorized package of sum rules
Author : poplar
Version : alpha
```

便说明已经成功引入*Þór*。如果你在使用过程中碰到什么困难，
或者遇到什么bug可以使用邮箱同作者联系。

类与函数

类 2

这一节我们将要介绍*Tyr*中如何定义费米子场 Filed 、矩阵类 Matrices 、传播子类 DE 。这些将作为我们的必要输入。

2.1 Filed

费米子场 Filed 是一个旋量。它由三部分组成：一个6×1的列矩阵表示其味道信息，一个3×1的列矩阵表示其颜色信息，一个4×1的旋量表示其位置信息。当我们不用考虑混合时，这些味道矩阵与色矩阵将可以用一个符号代替，因此*Tyr*将Filed 抽象为f、c、x 分别表示费米子场的味道、颜色和位置信息。在 *Tyr*中我们这样定义：

```
Field[f, c, s, x]
```

f、c、x 如前述，分别表示费米子场的味道、颜色和位置信息。符号 s 是旋量的矩阵元，s 的引入使得 *Tyr*不必特意去考虑矩阵得转置。它可以从0取至3，不过这些在计算中并不重要。
自然地，*Tyr*也定义了反费米子场FiledB，它同费米子场是一致的，除了它是一个1×4的行矩阵。

```
FieldB[f, c, s, x]
```

你可以在Mathematica的Mathematica里尝试上面代码，*Tyr*会默认给出Mathematica格式输出[1]。如果你并不希望TraditionalForm，可以使用Mathematica提供的StandardForm函数。

1: 对于正确格式的输入，*Tyr*将会显示类似于 $f(x)^{c}_{s}$ 和 $f(\bar{x})^{c}_{s}$ 的结果

仅对费米子提供支持，对目前的奇特态研究还有欠缺，因此在*Tyr*的后续更新中，将提供对矢量粒子的支持。

To Do

对矢量粒子 γ 、 W 、 Z 以及张量粒子g的输入进行支持，以方便*Tyr*可以计算含这些粒子的流算符。

2.2 Matrices

在针对流算符的运算中，最为重要的是4×4的矩阵。对于一个矩阵*Tzór*是如下定义的：

```
M[SI[{si1, si2}]]
```

M表示矩阵名称，两个si表示其矩阵元。*Tzór*只需要交换两矩阵元，便可以得到矩阵的转置。可以证明，对于所有4×4矩阵，只有16个矩阵是独立的。因此*Tzór*不推荐用户将矩阵显式地输入，而是在流算符计算中用可以区分的符号表示，而在后续计算中使用Mathematica提供的Replace函数将其替换成用户需要的格式。

2.3 DE

传播子DE是也分为颜色ci、味道f和位置si三个方阵，表示从x传播至y的f粒子。*Tzór*将其抽象如下：

```
DE[{f,f}, {x,y}][CI[{ci1,ci2}],SI[{si1,si2}]]
```

与此同时*Tzór*提供了逆传播子DEInverse：

```
DEInverse[{f,f},{x ,y}][CI[{ci1,ci2}],SI[{si1,si2}]]
```

在指明乘积顺序时，位置矩阵指标si不一定需要显式指出，*Tzór*提供了省去位置指标和颜色指标的输入格式：

```
DE[{f,f}, {x,y}][CI[{ci1,ci2}]]
DEInverse[{f,f}, {x,y}][CI[{ci1,ci2}]]
DE[{f,f}, {x,y}]
DEInverse[{f,f},{x,y}]
```

To Do

在后续更新中*Tzór*将提供对玻色子传播子的支持。

2.4 其它需要注意的类

除此之外，*Tzór*还提供了以下的类，方便用户使用。

```
DD[a,b]                         (*Dirac Delta function*)
eps[a,b,c]                      (*3 order Levi-Civita tensor*)
DE[a,b]                         (*delta tensor*)
lambda[a,b,n]                   (*genator of SU(3) groupe*)
sigma[a,b]                      (*sigma matrices*)
slash[x]                        (*slash x*)
```

```
CJM                             (*charge conjugate matrix*)
[esc]<[esc]M[esc]>[esc]         (*vacuum condension M*)
```

函数 3

*Tsór*封装了许多用于QCD求和规则的函数，它们功能强大、计算快捷、输入输出简单。大致分为五类，对流算符运算、对Feynman图计算、函数变换、信息读取以及辅助函数。

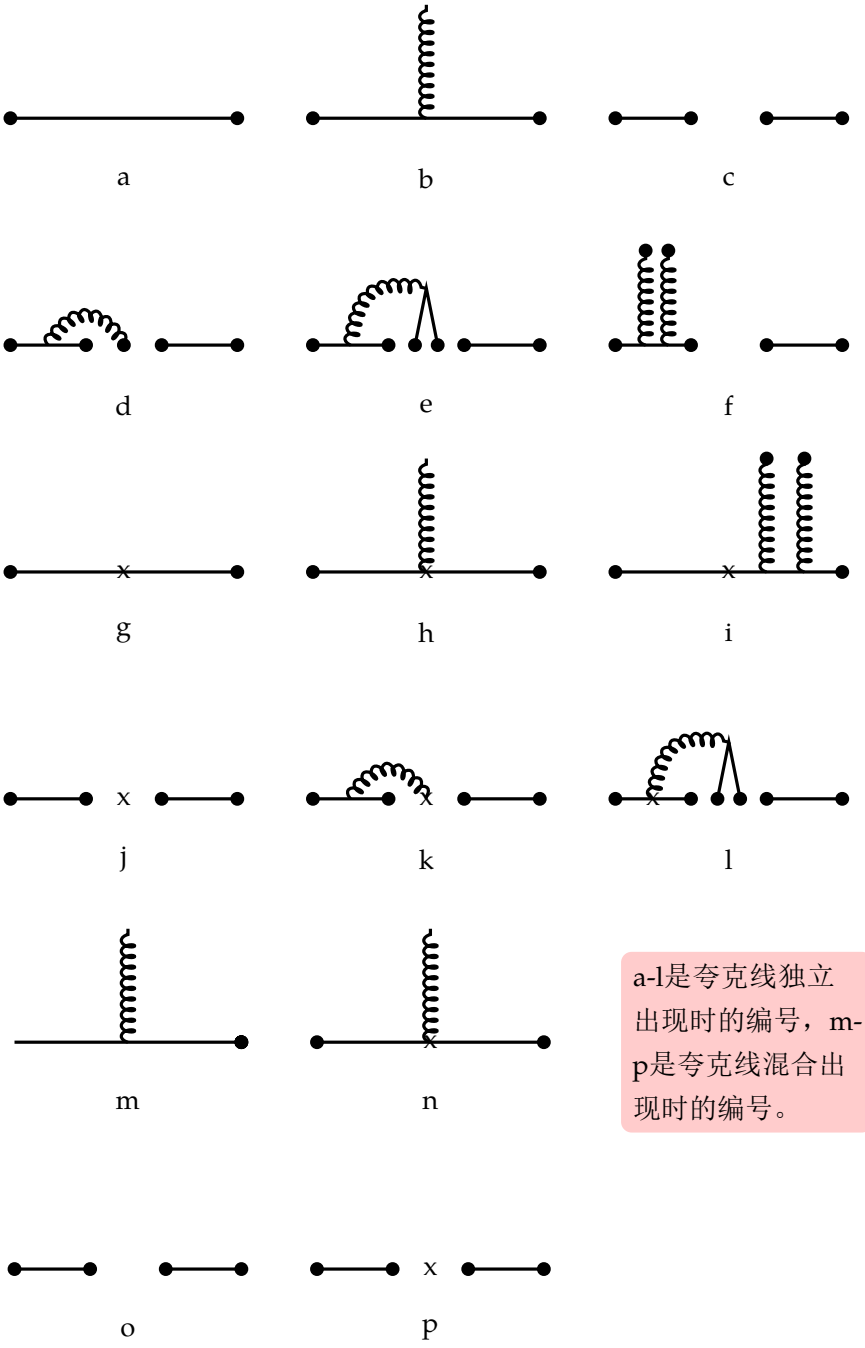
3.1 流算符

对流算符计算的核心是对编时乘积进行wick收缩。在真空期望下，wick收缩的结果会只剩下一系列传播子。*Tsór*为用户提供两个函数`wickContract`和`traceContract` 进行流算符的Wick收缩。
`wickContract`以一系列由场算符和矩阵矩阵相乘构成的流算符作为输入，同时以普通乘法连接的传播子和矩阵为输出。
`wickContract`实现Wick收缩的思路是利用`Mathematica`提供的`Riffle`和`Permutations`函数实现场算符的所有可能排列，并利用`Signature`判断重排后符号问题。
`wickContract`得到的结果尚带有位置指标si， `traceContract` 的任务是将其照矩阵乘法排序，使得最后结果不必含有位置指标si。
我们需要指出的是对于玻色子和费米子而言其结果的结构是不同的，费米子是一个4×4矩阵，而玻色子是一个数。不过不必担心，*Tsór*足够聪明，可以识别这种不同。
用户在定义好要使用的流后，可以按以下格式进行计算。

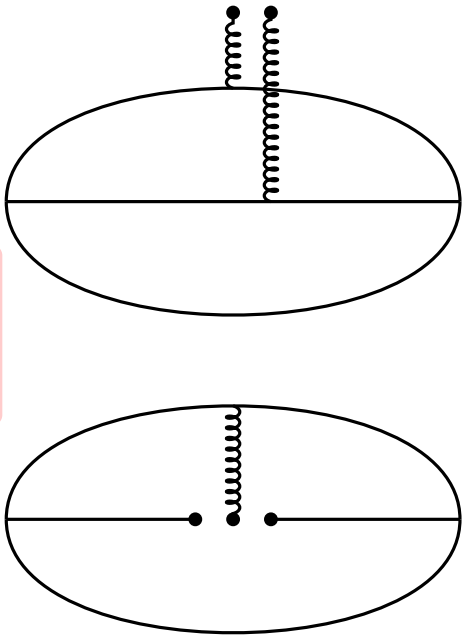
```
contract = wickContract[jc ** jcbar] // Expand
temp = Plus@@Table[traceContract[contract[[i]]],{i,Length[contract
    ]}]
```

3.2 Feynman图

QCD求和中需要计算大量的Feynman图，*Tsór*想要计算Feynman图，首先需要对图进行编号。对传播子进行如下编号后，*Tsór*便可以获得每一幅图独一无二的编号。除此之外，实际计算中我们会涉及到来源于两个不同的夸克线之间夸克凝聚同悬挂胶子之间组成混合凝聚。*Tsór*考虑了这种不同，并对组成这类真空凝聚量的传播子图单独编号。



a-l是夸克线独立出现时的编号，m-p是夸克线混合出现时的编号。



夸克线单独出现时（上图）图编号为“abb”，而混合出现时（下图）图编号为“amo”。

在计算Feynman图时，*Tsór*封装了一个函数`replace`，可以将Wick收缩中的传播子按照图编号对应替换。

```
dig = {"a","b","b"};
(*digs=feynCalc[n,k]*)
digs = Permutations[dig];
Plus@@Flatten[Table[replace[wickcontract[[i]],digs[[j]]],{i,Length
    [wickcontract]},{j,Length[dig]}]];
```

如果用户觉得写出所有Feynman图编号是繁琐的，*Tsór*封装了一个函数`feynCalc`。它可以给出对于n个夸克组成的流而言，在$O(x) = k$时所有可供我们计算的合法的流。默认情况下`feynCalc`舍弃了所有胶子动量不守恒的图、质量项大于二阶的图、三胶子及其以上凝

聚。如果用户不希望这样做，可以对feynQ函数进行修改。
除此之外，色指标的缩并在Feynman图计算中也是极为重要的。***Tzór***为此提供了NColorFactors函数。它可以自动识别需要计算的表达式中需要缩并的色指标以及其求和上限。并且为了提高运算速率，它会将以前的运算结果存储至factors.csv文件。用户如果在记事本中打开它的话，可以看到类似如下内容：

```
1755416550555155375,-16
3464993931337340818,32
4272833937615523678,32
5448561971756481330,96
7762675944865947294,6
...
```

前半部分是色矩阵对应的Hash值，后半部分是色矩阵收缩后的结果。尽管严格来讲Hash函数并非一个单值函数，但其稀疏性已经足以保证我们对不同的色矩阵得到相同的Hash值。当然其中有些项会重复被写入，这是因为Mathematica的循环Table是高度并行的，对于此***Tzór***并没有好的办法。不过这些重复项并不会影响计算结果只会拖慢运行效率，如果用户觉得factors.csv文件的内容不美观的话，可以自行清除。不过***Tzór***在之后会提供相关函数帮助用户做到这点。另外值得一提的是***Tzór***已经严格规定只允许数值结果存入factors.csv文件，所以用户如果发现自己的factors.csv文件含有非数值内容，请仔细检查自己的代码后，联系我们。
最后***Tzór***并不建议用户的factors.csv文件过大（超过用户硬盘读取速率的1/10），因为 NColorFactors 实际上是***Tzór***运算速度的瓶颈。对于不同类型的计算***Tzór***建议，使用不同的csv文件。用户可以在tzor.m中修改

```
filename = "mynewcsv.csv";
```

并在tzor.m所在目录下创建对应的csv文件。

To Do

在后续更新中***Tzór***将提供对factors.csv文件的整理。

3.3 函数变换

Tzór实现了两种QCD求和规则中所需要的变换。傅里叶变换和Broel 变换。傅里叶变换是从下式出发：

$$\int d^4x \frac{e^{ip\ldots x}}{x^s} = -\frac{i\pi^2 2^{4-2s}\left(-p^2\right)^{s-2}\Gamma(2-s)}{\Gamma(s)}$$

对于含有log的傅里叶变换只需要对式子两边的变量s求导即可。同时我们注意到含$\hat{x}$的部分需要对p进行求导。不过用户此时不必为这些事情烦恼，***Tzór***足够聪明它可以认出这些的。
Broel变换***Tzór***是通过公式

$$\mathscr{B}\left[\frac{2^{2-s}Q^{s-4}\Gamma\left(2-\frac{s}{2}\right)}{\Gamma\left(\frac{s}{2}\right)}\right]=\frac{2^{2-s}M^{s-2}}{\Gamma\left(\frac{s}{2}\right)}$$

实现的。***Tzór***会将等号两边的函数按照s的阶数展开，以便求取Borel变换后的结果。

```
fourierT[fun,x,p]
borelT[fun,Q,M]
```

你可能会发现二者输出的结果格式不一样。前者是一个函数，后者是一个替换表。这是在之后的***Tzór***更新计划之中的。

3.4 信息读取函数

如果用户希望开发属于自己的***Tzór***函数，***Tzór***提供了下面函数，以便用户可以快速访问计算中涉及到的各种信息。

- scalarQ 判断表达式是否是一个标量
- quarkQ 判断表达式是否是一个夸克
- ProgQ 判断表达式是否是一个传播子
- spin 读取位置矩阵元
- color 读取色矩阵元
- posandflovor 读取味道与位置信息
- unspin 隐藏位置矩阵元
- uncolor 隐藏色矩阵元
- ϵ
- δ
- λ
- operator 读取凝聚量

3.5 其它函数

除前述外***Tzór***还提供了下面的函数，分别用来标志非对易乘法、迹、转置、反粒子，判断set里是否含有case、计算变量的爱因斯坦求和约定、转换表达式为latex格式：

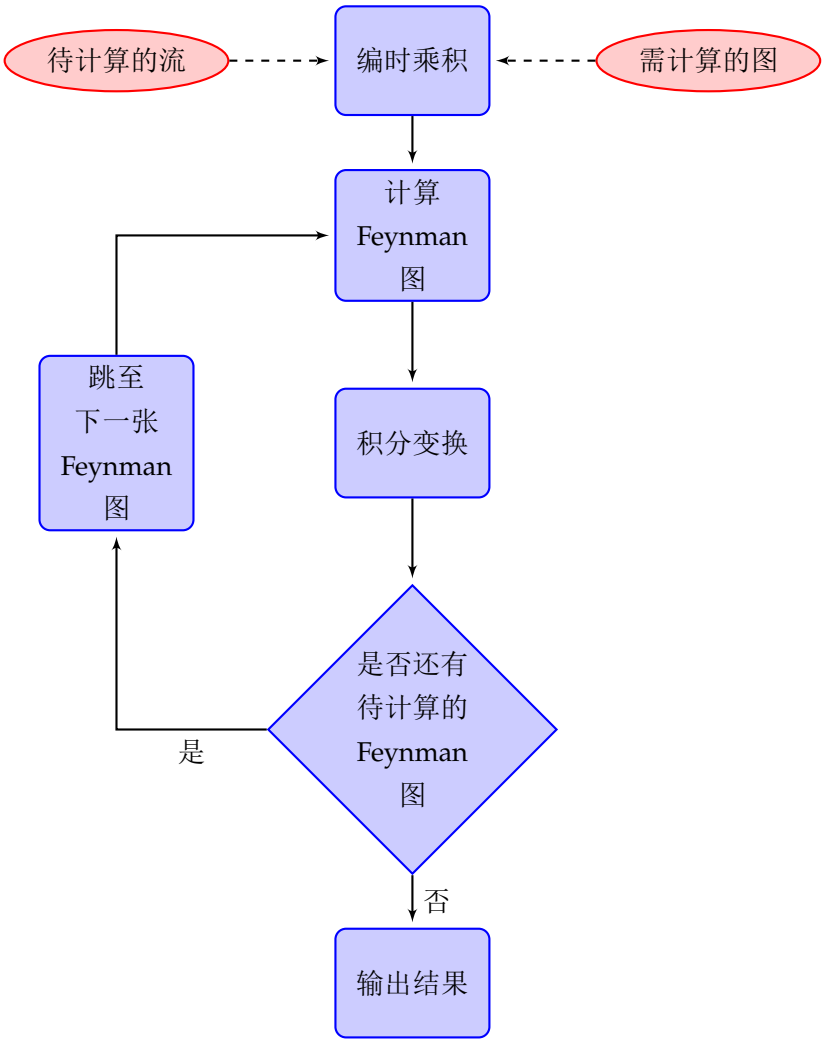
```
NM[a___, b__, c___]
Track[exp_]
Trans[exp_]
bar[exp_]
contentQ[set_,case_]
Einsum[exp_,{vars__, upper_}]
ToTeXForm[expr_]
```

计算

4 计算

4.1 总述

Tzór 的计算流程是类似于人类计算习惯的。用户只需要输入 *Tzór* 需要计算的流以及其共轭，*Tzór* 便能自动地进行下去。总的来说 *Tzór* 的计算分为三大块：编时乘积、图计算和积分变换。在下文中我们以流



4.2 编时乘积

编时乘积是所有计算的开始，前文已述 *Tzór* 使仅含夸克的场计算可以自动化实现。

4.3 Table of Contents

Another important part of a book is the table of contents. By default, in `kaobook` there is an entry for everything: list of figures, list of tables, bibliographies, and even the table of contents itself. Not everybody might like this, so we will provide a description of the changes you need to do in order to enable or disable each of these entries. In the following Table 4.1, each item corresponds to a possible entry in the TOC, and its description is the command you need to provide

Entry	Command to Activate
Table of Contents	`\setuptoc{toc}{totoc}`
List of Figs and Tabs	`\PassOptionsToClass{toc=listof}{\@baseclass}`
Bibliography	`\PassOptionsToClass{toc=bibliography}{\@baseclass}`

Table 4.1: Commands to add a particular entry to the table of contents.

to have such entry. These commands are specified in the attached style package,[1] so if you don't want the entries, just comment the corresponding lines.

1: In the same file, you can also choose the titles of these entries.

Of course, some packages, like those for glossaries and indices, will try to add their own entries. In such cases, you have to follow the instructions specific to that package. Here, since we have talked about glossaries and notations in Chapter **??**, we will biefly see how to configure them.

In a later section, we will see how you can define your own floating environment, and endow it with an entry in the TOC.

For the `glossaries` package, use the 'toc' option when you load it: `\usepackage[toc]{glossaries}`. For `nomencl`, pass the 'intoc' option at the moment of loading the package. Both `glossaries` and `nomencl` are loaded in the attached 'packages' package.

Additional configuration of the table of contents can be performed through the packages `etoc`, which is loaded because it is needed for the margintocs, or the more traditional `tocbase`. Read the respective documentations if you want to be able to change the default TOC style.[2]

2: (And please, send me a copy of what you have done, I'm so curious!)

4.4 Page Layout

Besides the page style, you can also change the width of the content of a page. This is particularly useful for pages dedicated to part titles, where having the 1.5-column layout might be a little awkward, or for pages where you only put figures, where it is important to exploit all the available space.

In practice, there are two layouts: 'wide' and 'margin'. The former suppresses the margins and allocates the full page for contents, while the latter is the layout used in most of the pages of this book, including this one. The wide layout is also used automatically in the front and back matters.

To change page layout, use the `\pagelayout` command. For example, when I start a new part, I write:

```
\pagelayout{wide}
\addpart{Title of the New Part}
\pagelayout{margin}
```

4.5 Numbers & Counters

In this short section we shall see how dispositions, sidenotes and figures are numbered in the `kaobook` class.

By default, dispositions are numbered up to the section. This is achieved by setting: `\setcounter{secnumdepth}{1}`.

The sidenotes counter is the same across all the document, but if you want it to reset at each chapter, just uncomment the line

```
\counterwithin*{sidenote}{chapter}
```

in the `styles/style.sty` package provided by this class.

Figure and Table numbering is also per-chapter; to change that, use something like:

```
\renewcommand{\thefigure}{\arabic{section}.\arabic{figure}}
```

4.6 White Space

One of the things that I find most hard in LaTeX is to finely tune the white space around objects. There are not fixed rules, each object needs its own adjustment. Here we shall see how some spaces are defined at the moment in this class.

Attention! This section may be incomplete.

Space around figures and tables

```
\renewcommand\FBaskip{.4\topskip}
\renewcommand\FBbskip{\FBaskip}
```

Space around captions

```
\captionsetup{
    aboveskip=6pt,
    belowskip=6pt
}
```

Space around displays (*e.g.* equations)

```
\setlength\abovedisplayskip{6pt plus 2pt minus 4pt}
\setlength\belowdisplayskip{6pt plus 2pt minus 4pt}
\abovedisplayskip 10\p@ \@plus2\p@ \@minus5\p@
\abovedisplayshortskip \z@ \@plus3\p@
\belowdisplayskip \abovedisplayskip
\belowdisplayshortskip 6\p@ \@plus3\p@ \@minus3\p@
```

Mathematics and Boxes 5

5.1 Theorems

Despite most people complain at the sight of a book full of equations, mathematics is an important part of many books. Here, we shall illustrate some of the possibilities. We believe that theorems, definitions, remarks and examples should be emphasised with a shaded background; however, the colour should not be to heavy on the eyes, so we have chosen a sort of light yellow.[1]

1: The boxes are all of the same colour here, because we did not want our document to look like Harlequin.

Definition 5.1.1 *Let (X, d) be a metric space. A subset $U \subset X$ is an open set if, for any $x \in U$ there exists $r > 0$ such that $B(x, r) \subset U$. We call the topology associated to d the set τ_d of all the open subsets of (X, d).*

Definition 5.1.1 is very important. I am not joking, but I have inserted this phrase only to show how to reference definitions. The following statement is repeated over and over in different environments.

Theorem 5.1.1 *A finite intersection of open sets of (X, d) is an open set of (X, d), i.e τ_d is closed under finite intersections. Any union of open sets of (X, d) is an open set of (X, d).*

Proposition 5.1.2 *A finite intersection of open sets of (X, d) is an open set of (X, d), i.e τ_d is closed under finite intersections. Any union of open sets of (X, d) is an open set of (X, d).*

You can even insert footnotes inside the theorem environments; they will be displayed at the bottom of the box.

Lemma 5.1.3 *A finite intersection[a] of open sets of (X, d) is an open set of (X, d), i.e τ_d is closed under finite intersections. Any union of open sets of (X, d) is an open set of (X, d).*

[a] I'm a footnote

You can safely ignore the content of the theorems. . . I assume that if you are interested in having theorems in your book, you already know something about the classical way to add them. These example should just showcase all the things you can do within this class.

Corollary 5.1.4 (Finite Intersection, Countable Union) *A finite intersection of open sets of (X, d) is an open set of (X, d), i.e τ_d is closed under finite intersections. Any union of open sets of (X, d) is an open set of (X, d).*

Proof. The proof is left to the reader as a trivial exercise. Hint: Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. □

Definition 5.1.2 *Let (X, d) be a metric space. A subset $U \subset X$ is an open set if, for any $x \in U$ there exists $r > 0$ such that $B(x, r) \subset U$. We call the topology associated to d the set τ_d of all the open subsets of (X, d).*

Here is a random equation, just because we can:

$$x = a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \cfrac{1}{a_4}}}}$$

Example 5.1.1 Let (X, d) be a metric space. A subset $U \subset X$ is an open set if, for any $x \in U$ there exists $r > 0$ such that $B(x, r) \subset U$. We call the topology associated to d the set τ_d of all the open subsets of (X, d).

Remark 5.1.1 Let (X, d) be a metric space. A subset $U \subset X$ is an open set if, for any $x \in U$ there exists $r > 0$ such that $B(x, r) \subset U$. We call the topology associated to d the set τ_d of all the open subsets of (X, d).

As you may have noticed, definitions, example and remarks have independent counters; theorems, propositions, lemmas and corollaries share the same counter.

Remark 5.1.2 Here is how an integral looks like inline: $\int_a^b x^2 dx$, and here is the same integral displayed in its own paragraph:

$$\int_a^b x^2 dx$$

We provide two files for the theorem styles: plaintheorems.sty, which you should include if you do not want coloured boxes around the-

orems; and mdftheorems.sty, which is the one used for this document.[2] Of course, you will have to edit these files according to your taste and the general style of the book.

2: The plain one is not showed, but actually it is exactly the same as this one, only without the yellow boxes.

5.2 Boxes & Custom Environments [3]

Say you want to insert a special section, an optional content or just something you want to emphasise. We think that nothing works better than a box in these cases. We used `mdframed` to construct the ones shown below. You can create and modify such environments by editing the provided file environments.sty.

3: Notice that in the table of contents and in the header, the name of this section is 'Boxes & Environments'; we achieved this with the optional argument of the `section` command.

Title of the box

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

If you set up a counter, you can even create your own numbered environment.

Comment 5.2.1

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

5.3 Experiments

It is possible to wrap marginnotes inside boxes, too. Audacious readers are encouraged to try their own experiments and let me know the outcomes.

title of margin note

Margin note inside a kaobox.
(Actually, kaobox inside a marginnote!)

I believe that many other special things are possible with the `kaobook` class. During its development, I struggled to keep it as flexible as possible, so that new features could be added without too great an effort. Therefore, I hope that you can find the optimal way to express yourselves in writing a book, report or thesis with this class, and I am eager to see the outcomes of any experiment that you may try.

Appendix

A

Heading on Level 0 (chapter)

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

A.1 Heading on Level 1 (section)

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Heading on Level 2 (subsection)

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information

about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Heading on Level 3 (subsubsection)

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Heading on Level 4 (paragraph) Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

A.2 Lists

Example for list (itemize)

- First item in a list
- Second item in a list
- Third item in a list
- Fourth item in a list
- Fifth item in a list

Example for list (4*itemize)

- First item in a list
  - First item in a list
    - First item in a list
      - First item in a list
      - Second item in a list
    - Second item in a list
  - Second item in a list
- Second item in a list

Example for list (enumerate)

1. First item in a list
2. Second item in a list
3. Third item in a list
4. Fourth item in a list
5. Fifth item in a list

Example for list (4*enumerate)

1. First item in a list
   a) First item in a list
      i. First item in a list
         A. First item in a list
         B. Second item in a list
      ii. Second item in a list
   b) Second item in a list
2. Second item in a list

Example for list (description)

First item in a list
Second item in a list
Third item in a list
Fourth item in a list
Fifth item in a list

Example for list (4*description)

First item in a list

First item in a list

First item in a list

First item in a list

Second item in a list

Second item in a list

Second item in a list

Second item in a list

Greek Letters with Pronounciation

Character	Name	Character	Name
α	alpha *AL-fuh*	ν	nu *NEW*
β	beta *BAY-tuh*	ξ, Ξ	xi *KSIGH*
γ, Γ	gamma *GAM-muh*	o	omicron *OM-uh-CRON*
δ, Δ	delta *DEL-tuh*	π, Π	pi *PIE*
ϵ	epsilon *EP-suh-lon*	ρ	rho *ROW*
ζ	zeta *ZAY-tuh*	σ, Σ	sigma *SIG-muh*
η	eta *AY-tuh*	τ	tau *TOW (as in cow)*
θ, Θ	theta *THAY-tuh*	υ, Υ	upsilon *OOP-suh-LON*
ι	iota *eye-OH-tuh*	ϕ, Φ	phi *FEE, or FI (as in hi)*
κ	kappa *KAP-uh*	χ	chi *KI (as in hi)*
λ, Λ	lambda *LAM-duh*	ψ, Ψ	psi *SIGH, or PSIGH*
μ	mu *MEW*	ω, Ω	omega *oh-MAY-guh*

Capitals shown are the ones that differ from Roman capitals.