The Tzór class

Use this document as a manual

Tzór

Theorized package of sum rules

Poplar xlchen zzchen dklian *

September 23, 2022

An Awesome Publisher

* sysu.edu

The *Tzór* class

Disclaimer

Tzór is a Mathematica package designed for QCD summation systems. Although it still lacks a lot of features, it is powerful enough to handle most of the problems encountered in the calculation of QCD summation rules.

Colophon

The manual of *Tzór* is based on the code kaobook LaTeX by KOMA-Script and LaTeX.
You can find them in Here
`https://github.com/fmarotta/kaobook`.

Publisher

First printed in Sep. 2020 by An Awesome Publisher

One can call Tyre a city of ruins, built out of ruins.

– Ernest Renan

Contents

List of Figures

List of Tables

Introduction 1

1.1 Why call me Tzór

Tzór is a city in Lebanon, which is generally called Tyre in the Christian world or Ṣūr in the Islamic world. Tzór is its Hebrew name. In addition to this, the Akkadians called it Ṣurru, the Phoenicians called it Ṣūr, and the Greeks called it Týros. And thus derived into Tyrus in Latin and Tyre in English. Tzor was founded in 2750 BC and is in fact one of the oldest continuously inhabited cities.

There are many legends about the founding of Tzor. One of the most common is that the god Melqart Heracles built the city to attract the nymph Tyros, and named it after her. Therefore, Melqart was regarded as his devine patron by Tzor. Another story says that Usoos, the founder of Tzor, used a tree trunk to sail on the sea, the trunk also became the first vessel, and sailed to a small island and established Tzor called Ushu there. In Greek mythology, the princess Europa, who was kidnapped by Zeus to Crete, came from Tzor. And the princes of Tzor, who followed in search of the princess, also brought alphabet to the Greeks.

Subsequently, Tzor was under the rule of the Egyptian pharaohs. During this time, the Tyrians had established an industry of a rare and expensive purple dye known as Tyrian purple or Royal purple. It is said that while Melqart Hercules, the devine patron of Tzor, was walking by the sea with the nymph Tyros, his dog bit a soft snail and dyed its lips purple. Tyros wanted a dyed dress in the same color. Thus, Tyrian Purple was born. The people of this area were also called by the Greeks "Phoenicia", means purple people, that is, the Phoenicians. It is recorded that some sailors from Tzor reached the British Isles during this period, where they bought tin for weapons. Herodotus recorded in *History* that the pharaohs of Egypt once hired a team of Phoenician sailors to complete the first voyage around the African continent from the Red Sea.

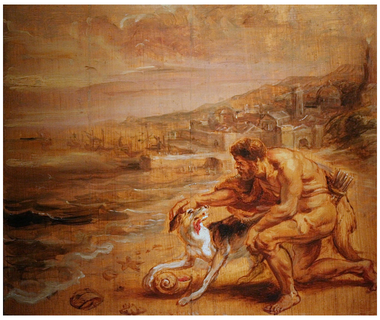


Figure 1.1: *La decouverte de la pourpre*, Sir Peter Paul Rubens

As Egypt's power declined, Phoenician Tzor became independent. The Phoenicians gradually established trade hegemony in the Eastern Mediterranean. Even the Mediterranean Sea is called the Tyrian

Sea. Queen Dido, the princess of Tzor, came to Tunisia after losing a political battle and being exiled. And here she established the city of Carthage famed in the western Mediterranean. Euclid, the father of geometry, was born in Tzor in 325 BC.

Tzor was proud, and its pride made God himself jealous. Therefore, God himself prophesied for Tzor: destroy and destroy. The Hittite and Assyrian empires have conquered Tzor many times, and was finally completely destroyed by Ashurbanipal in 631 BC. But soon Tzor returned to its former prosperity. As Assyria falls, Babylonian kingdom rises. The Babylonian king Nebuchadnezzar II launched a 13-year siege of Tzor in 586 BC and finally brought Tzor to its submission.

After the fall of Babylon, Cyrus the Great of Achaemenid Persia conquered Tzor again in 539 BC. In 392 BC, the Tyreans secretly agreed to the Cypriot prince Evagoras to take Tzor, and the Persians again attacked Tzor and quelled the rebellion ten years later.

In 333 BC, Alexander the Great defeated the Persian emperor Darius III, and the Phoenician city-states on the Mediterranean coast opened their gates to welcome the Great and his army, except for Tzor. Tzor rejected Alexander the Great's proposal to enter the city to worship Hercules. Enraged by this behavior, Alexander launched a seven-month siege of Tzor. After the conquest of Tzor, Alexander the Great demolished its old town and used the resulting stones to build a causeway to Tzor. Tzor has since changed from an island into a peninsula.

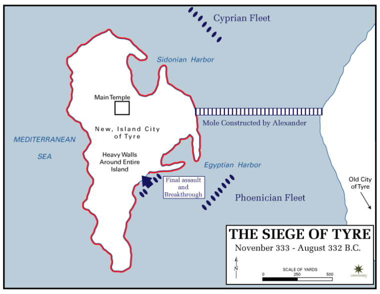


Figure 1.2: siege of Tzor, and causeway by Alexander the Great

During the Diadochi, Tzor was first annexed by Ptolemy I of Egypt, then besieged and conquered by Antigonus I. Antigonus's successor, Demetrius, later handed it over to Ptolemy, but the latter was again besieged and conquered by Antiochus III of the Seleucid Empire after seventy years.

With the conquest of Seleucus by the Roman Empire, Tzor became part of the Roman province of Syria, as a free city of the Empire. Tzor also once enjoyed peace due to the Pax Romana, which lasted more than 200 years. But the jealousful days could not last long. With the decline of the empire, the Sassanid Persia, the Arab Empire, the Fatimid Dynasty, the Crusaders, and the Mamluks all conquered this ancient Eastern Mediterranean city. Even now, the city of Tzor is still within the range of the artillery of both Israel and Palestine. In fact, during the nearly 5,000 years since the city was built, Tyre would fall into a cycle of destruction-rebirth-prosperity-destruction due to natural and man-made disasters such as earthquakes, tsunamis, and wars every period about 70 years .

Tzor's experience of constant destruction and constant rebirth is very similar to the process of scientific research. In scientific research, we constantly abandon our previous practice due to encountering new difficulties, and fall into the cycle of method-problem-thought-method. But in the meantime, as with Tzor, there was something to be done. Based on this idea, we named this package *Tzór*. For in fact, our research work was built from ruins just like Tzor.

Tzór is a package based on `Mathematica`. We encapsulate the tedious and complex leading order calculations in the QCD sum rules into a specific function. Only need to call these functions to realize the relevant calculation of the QCD sum rules.Its input is extremely simple, and it only needs to enter the stream operator to perform the calculation. Secondly, its computing process is similar to human computing habits, so that it can easily test and analyze the results of some digrams. At the same time its output is also easy to read.

1.2 What Tzór can do

Tzór is committed to solving the calculation of the sum rules. Many functions it encapsulates make the calculation simple and the code easy to understand. But this also means that the encapsulated functions are not necessarily required by the user, and at the same time, the functions required by the user are not necessarily encapsulated. Therefore it is necessary to do a summary.

Tzór"s features :

Fermion Fermion field is basic of almost currents, in taht you can define special fermion in *Tzór*;

Gluon Field Strength As above, gluon field strength is useful in calculations of hybird states or gluon balls;

Matrix Naturally, matrix is needful;

Dirac algebra *Tzór* only provides the symbols of Dirac algebra, but it can not calculate them for now. Users can use other package such as `FeynCalc` to deal with it;

propagator propagator can be a intermediate results or be an input at first;

Wick Contract Tzór provides two styles of Wick contraction, one including explicitly matrix index via normal times, another not via matrix times;

Feynman Digrams The calculations of Tzór are based on every Feynman digrams, which means Tzór can't distinguish two digrams only shuffling quarks or gluons. But no need to worry, we only need to calculate all possible permutations. `Mathematica` wil help us to deal it;

Fourier Transformer Tzór provides a d-dimension Fourier transformer, and a Fourier transformer convolve;

Borel Transformer Meanwhile Tzór provides a Borel transformer, although it not needful in popular calculation;

Color Struct Calculations Not as Dirac algebra Tzór can not only define color structs, but also can calculate them into a special number;

Information Get Tzór provides many interface to get information we intrested.

Except these, Tzór has others features, we will describes these laterly.

1.3 How to use `Tzór`

You can visit Tzór on github and you will get a `Mathematica` package called *tzor.m* and a data file called *factors.csv*. Just copy them to your working directory. If the csv file is damaged, you can create a new file with the same name, and write below content:

```
1,1
```

then creat your `Mathematica` notebook, and write below code:

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

when it shows

```
Tz\'or for Theorized package of sum rules.
Get Lastest Version : Tzor@github
Author : poplar, xlchen, zzchen, dklian
Version : alpha
```

It means that Tzór has been successfully imported. If you encounter any difficulties during use, or encounter any bugs, you can contact the author by email amazingpoplar@gmail.com.

Attentions

1. Due to a known `Mathematica` bug, `FeynCalc` 9.3.1 is required;
2. The same bug caused FeynCal to be unable to calculate the dot product of some Dirac algebra;
3. In order to avoid variable pollution, it is not recommended to use $\mu 1$,...; $\nu 1$,...; $\eta 1$,...;k1,... in your notebook because these indicators are built-in dummy indicators used for summation or internal momentums;
4. Others errors we have not found for now.

Physics in Tzór

Physics 2

Functions and variables in $\mathcal{T}z\acute{o}r$ follow Hungarian notation wherever possible. In this section we will introduce how to define physics quantity in $\mathcal{T}z\acute{o}r$. They're the basic elements of inputs and results of our calculations.

2.1 Filed

Fermion `QFiled` is made up by three parts: a 6×1 column matrix for its flavour, and a 3×1 column matrix for its color, and a 4×1 spinor for its position. If we don't consider mixing of each others, these matrix can be represent as one symbol. In that $\mathcal{T}z\acute{o}r$ abstract the information about flavour, and colour and position of `QFiled` as q、c、x. The defination in $\mathcal{T}z\acute{o}r$:

```
QField[q, c, s, x]
```

means a flavour q, colour c, position$x$ quark. Symbol s is spinor's index. In that $\mathcal{T}z\acute{o}r$ need not to deal with transpose quarks.

Similarly, $\mathcal{T}z\acute{o}r$ also define anti-quarks `QFiledB`, it just like quarks.

```
QFieldB[q, c, s, x]
```

Users can try code above in `Mathematica` notebook. $\mathcal{T}z\acute{o}r$ will show results as style `TraditionalForm` [1] defaultly. If you not like style `TraditionalForm`, you can use `StandardForm` or others styles you like.

1: If your inputs are right, output with $\mathcal{T}z\acute{o}r$ like $q(x)^c_s$ and $\bar{q}(x)^c_s$

Gluon field strength are neccessary in researches of hybird states and gluon ball. represents a gluon with colour n, and Lorentz struct $\{\mu, \nu\}$ at position x. In $\mathcal{T}z\acute{o}r$, it defines as [2] :

2: output like $G^n_{\mu,\nu}(x)$

```
GField[n, x][li[{\[Mu], \[Nu]}]]
```

And these quantity have been overloaded to adapt to the time neglecting some unimportant information.

2.2 Matrices

4×4 martrices $M_{si1,si2}$ are neccessary, and it is defined as[3] :

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

M is the `Head` of the matrix, and sis for its indices. With only exchanging the two indices, Users will get transpose of matrix in Tzór. There are only 16 independent matrices for all 4×4 matrices. Therefore, Tzór does not recommend that users input the matrix explicitly, but use a distinguishable symbol in the currents operator calculation, and use the `Replace` function provided by `Mathematica` to replace it in subsequent calculations. into the format required by the user.

Dirac matrices and metric are special 4×4 martrices. In Tzór they have unique symbols to represent[4] :

```
gamma[\[Mu]]
gamma[5]
sigma[\[Mu], \[Nu]]
slash[p]
metric[\[Mu], \[Nu]]
fourVector[x, \[Mu]]
CJM
```

Tzór can distinguish these symbols as Dirac algebra. Although Tzór can't calculate the algebra for now, it can hold the noncommutative order in calculations.

3: output like $M_{si1,si2}$

4: outputs like γ^{μ} γ^{5} $\sigma^{\mu,\nu}$ $\hat{p}$ $g_{\mu,\nu}$ x_{μ} and C

2.3 Propagator

Quark propagator $S^{q,a,b}_{\alpha,\beta}(y-x)$ is defined as:

```
DE[{q, q}, {x , y}][ci[{a, b}], li[{\[Alpha], \[Beta]}]]
```

and gluon propagator:

```
GE[GField[n1, x][li[{\[Mu]1, \[Nu]1}]], GField[n2, y][li[{\[Mu]2, \[Nu]2}]]]
```

and there are overloaded functions for these propagators.

Except propagator, we also need Feynmann amplitude, which defined as:

```
FeynAmpD[q]
FeynAmpD[{q, m}]
FeynAmpD[{q, m, 5}]
FeynAmpD[{q1, m}, {q2, m, 6}]
```

2.4 Condesates

Condesates are core of QCD sum rules, *Tzór* provides symbols or functions for chiral, hybird, double gluon and triple gluon condesates and mass.

```
chiral[q]
hybrid[q]
doubleG
tripleG
mass[q]
```

Rather than, `dimension` will give thier dimensions.

```
mass[q] chiral[q]/(2 \[Pi]^2 x^2) slash[x]
dimension[%]
dimension /@ {mass[q], chiral[q]^7, hybrid[q] tripleG, doubleG/(23 \[Pi]), (mass[q] tripleG)/(8 \[Pi]^2 p) gamma[\[Mu]]}
```

`dimension` is smart to deal with complex inputs, and it has `Listable` attributions.

2.5 Colour

Colour is a group $SU(3)$, there are three symbols for it in *Tzór*:

```
eps[a, b, c]
delta[a, b]
lambda[a, b, n]
```

Not as Dirac algebra *Tzór* can not only define color structs, but also can calculate them into a special number.

> **Attentions**
>
> The variables b, c and Q mean heavy quarks, so try to use them nowhere but as quarks.

Functions 3

Tzór encapsulates many functions for QCD sum rules, which are powerful, fast in calculation, and simple in input and output. It is roughly divided into five categories, operation to currents operators, calculation of Feynman digram, function transformation, information gets and sets functions.

3.1 Wick Contract

At the core of the computation of currents operators is the Wick contraction of time-order products. Under the vacuum expectation, the result of the Wick contraction will be only a series of propagators. Tzór provides two functions with different style `wickContract` and `traceContract` to calculate Wick contraction.

`wickContract` takes as input a series of flow operators consisting of field operators' and matrices' multiplications, and takes as output the propagators and matrices connected by ordinary multiplication.

The algorithm of `wickContract` is as below:

1. input a currents made up by matrices, and quarks-antiquarks, and gluons, and some factors;
2. get the list of quarks and antiquarks as quarklist and the list of gluons as gluons list and get other factors as factorsLits;
3. calculate the signature of iQuarkList;
4. permutate all possible antiquarks, and riffile them with quarks, get a list as oQuarksLists;
5. replace quark-antiquarks by quark's propagator, and times signatures of iQuarkList and of oQuarksLists;
6. replace gluon-gluon by gluon's propagator;
7. times factorsLits as output.

```
jc = ((QFieldB[s, a1, \[Alpha]1, x] ** M1[li[{\[Alpha]1, \[Beta]1}]] ** QField[c, a1, \[Beta]1,
 x])) ** (QFieldB[c, b1, \[Sigma]1, x] ** M1[li[{\[Sigma]1, \[Epsilon]1}]] ** QField[s, b1, \[
Epsilon]1, x])
jcbar = (QFieldB[s, b2, \[Sigma]2, 0] ** M2[li[{\[Sigma]2, \[Epsilon]2}]] ** QField[c, b2, \[
Epsilon]2, 0]) ** (QFieldB[c, a2, \[Alpha]2, 0] ** M2[li[{\[Alpha]2, \[Beta]2}]] ** QField[s,
a2, \[Beta]2, 0])
```

```
wick = wickContract[jc ** jcbar] // Expand
```

If users try to evaluate codes above, the output should be like below

$$M1_{\alpha1\beta1}M1_{\sigma1\epsilon1}M2_{\alpha2\beta2}M2_{\sigma2\epsilon2}S^{c,a1,a2}_{\beta1,\alpha2}(x)S^{s,a2,a1}_{\beta2,\alpha1}(-x)S^{c,b2,b1}_{\epsilon2,\sigma1}(-x)S^{s,b1,b2}_{\epsilon1,\sigma2}(x)$$

the indices $\alpha1\ \alpha2\cdots$ is indices of matrices, which will give the order of matrices times and traces. In fact, *Tzór* encapsulates a function `traceContract` who can give the right order and traces. Its algorithm is:

1. input `wickContract`'s result;
2. create a graph by indices of matrices and of propagators;
3. find circles and the isolated line(only one) of the graph;
4. make up the result by order traversing these circles and the line;
   a) inverse order gives a transpose;
   b) circle gives a trace;
5. times others factors as output.

Then, users can try evaluate the codes below[1] :

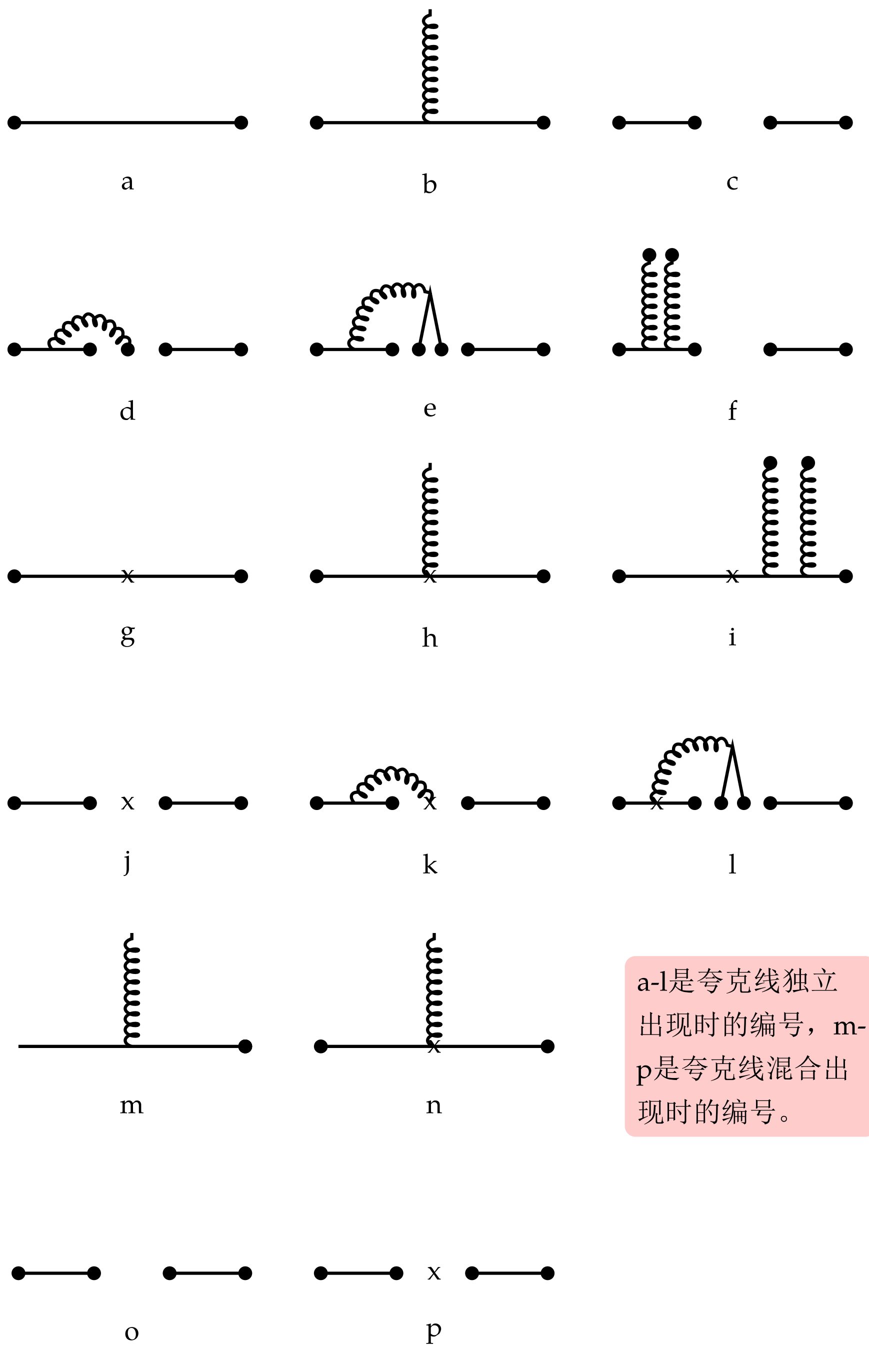
```
traceContract[wick]
```

and will get right order by matrices and propagators.

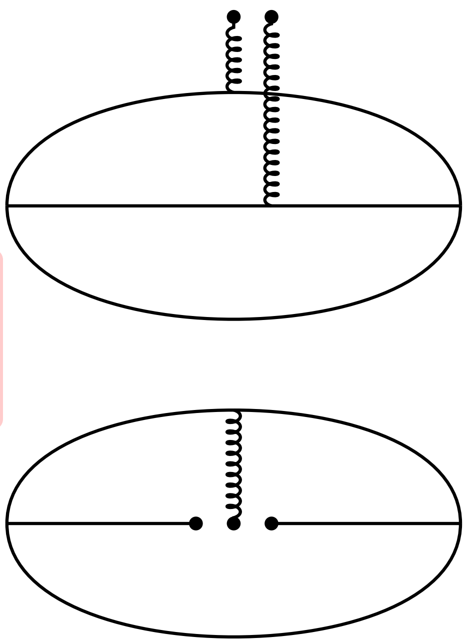
1: the result is $tr(S^{c}_{a1,a2}(x).M1.S^{s}_{a2,a1}(-x).M2)tr(S^{s}_{b1,b2}(x).M2.S^{c}_{b2,b1}(-x).M1)$

3.2 Propagators

QCD求和中需要计算大量的Feynman图，*Tzór*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，*Tzór*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。*Tzór*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，*Txór*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，*Txór*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：

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

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：

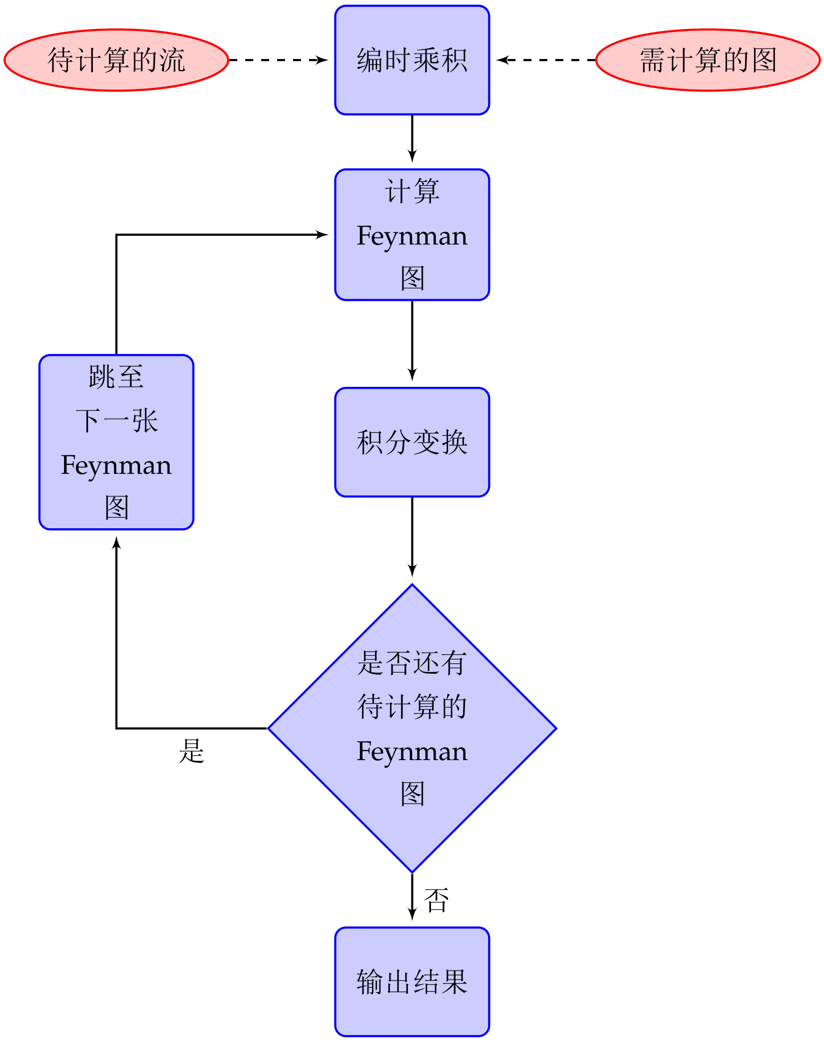
```
NM[a___, b__, c___]
Track[exp_]
Trans[exp_]
bar[exp_]
contentQ[set_,case_]
Einsum[exp_,{vars__, upper_}]
ToTeXForm[expr_]
```

Calculation with $\mathscr{T}$zór

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 𝒯𝓍ó𝓇 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 theorems; 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.