12

Faux processes

The wave function for a non-periodic interaction is written

$$\Psi(t \geq t_0) = \psi_0(t) + \int_0^{a(t-t_0)} \underline{\psi}_1(t,\tau)d\tau \qquad (12.1)$$

where variables other than time are not expressed. It is assumed that the component ψ_1 is a quantum jump away from ψ_0 in that it contains new particles or annihilates old ones. It is therefore the precursor of a ready component in the q-rule format and is underlined as such. The constant *a* has units of inverse time. The second integral includes a time *t* that is independent of a stochastic choice, and another unitless parameter τ that is a function of stochastic choice. At every moment of time the Schrödinger equation initiates a 'possible' evolution that the second component in Eq. 12.1 carries to completion as though it had actually occurred. It is the sum of these empirically 'unreal' evolutions coming off of ψ_0 that are called *faux processes*. At the onset of each one the parameter τ is $\tau_0 = 0$.

Starting at time t_0 and skipping to finitely separated times t_1, t_2, t_3, etc., the resulting integrand as a function of *t* and τ is equal to

t_0 : $\boldsymbol{\psi_1(t_0, \tau_0)d\tau}$

t_1 : $\psi_1(t_1, \tau_0)d\tau$ + $\boldsymbol{\psi_1(t_1, \tau_1)d\tau}$

t_2 : $\psi_1(t_2, \tau_0)d\tau$ + $\psi_1(t_2, \tau_1)d\tau$ + $\boldsymbol{\psi_1(t_2, \tau_2)d\tau}$ (12.2)

t_3 : $\psi_1(t_3, \tau_0)d\tau$ + $\psi_1(t_3, \tau_1)d\tau$ + $\psi_1(t_3, \tau_2)d\tau$ + $\boldsymbol{\psi_1(t_3, \tau_3)d\tau}$

t_4 : $\psi_1(t_4, \tau_0)d\tau$ + $\psi_1(t_4, \tau_1)d\tau$ + $\psi_1(t_4, \tau_2)d\tau$ + $\psi_1(t_4, \tau_3)d\tau$ + $\boldsymbol{\psi_1(t_4, \tau_4)d\tau}$

t_5 : *etc.*

where the intervals between t_0, t_1, t_2, etc. are really a continuum of infinitesimal intervals in the variable t.

The ready component $\psi_1(t_0, \tau_0)d\tau$ at time t_0 is advanced by the Schrödinger equation along the diagonal of *bold face* components in the array. This diagonal shows the evolution of the process that begins at t_0 and proceeds independent of other processes that are initiated at other times. A new process begins at each moment of time because the first component ψ_0 in Eq. 12.1 continuously feeds current into the second component. Continuity of the Schrödinger equation requires that the state ψ_1 at the head of each diagonal is functionally identical with ψ_0 and becomes the new function ψ_1 *only after* moving down the diagonal for a time ΔT. This is difficult to display in Eq. 12.1 or in the array of Eq. 12.2, so we just state it as something to remember when considering this equation and this array. When writing these equations and other q-rule equations in this book we have generally ignored the transition time ΔT and the associated uncertainty in energy.

It is the interaction that produces the array in Eq. 12.2 from the start, where the interaction Hamiltonian initiates each *infinitesimal* faux process beginning at time t_0. At every moment along the way it generates an infinitesimal Schrödinger process that is empirically unreal, and it will continue to do so until the initial component ψ_0 has diminished to zero or has otherwise been disengaged. But while the interaction Hamiltonian initiates these processes it cannot itself bring the array to a stochastic conclusion. That is why we need the q-rules to decide when to collapse all those faux processes and make one of them an empirical reality.

The standard Copenhagen interpretation of quantum mechanics never gets beyond Eq. 12.2. All the horizontal components in the array at a time like t_4 represent possible states of the system at that time, and their total square modulus is the probability that there has been a stochastic hit by that time. Objective reality is not the issue from a Copenhagen point of view. The meaning of these component magnitudes has only to do with the probability of their being observed. But from a q-rule point of view observation has nothing to do with the collapse because a stochastic choice is an *objective choice*. Collapse does not depend on the presence or absence of an observer.

Only the first component along any horizontal line of the array is a launch component for only it receives probability current directly from the realized component ψ_0. Therefore, only the first component in the array can be stochastically chosen. If that happens at time $t_{sc} = t_5$, then following t_3 the array in Eq. 12.2 will be.

$t_4: \psi_1(t_4, \tau_0)d\tau + \psi_1(t_4, \tau_1)d\tau + \psi_1(t_4, \tau_2)d\tau + \psi_1(t_4, \tau_3)d\tau + \psi_1(t_4, \tau_4)d\tau$

$t_5: \psi_1(t_5, \tau_0)$

$t_6: \qquad \psi_1(t_6, \tau_1)$ (12.3)

$t_7: \qquad\qquad \psi_1(t_7, \tau_2)$

$t_8: \qquad\qquad\qquad$ etc.

The third q-rule requires that all of the off-diagonal components in Eq. 12.3 are equal to zero after t_5, and that the diagonal component is realized and normalized. The latter is accomplished by removing $d\tau$ from each of the diagonal terms. The first few realized diagonals in this equation, beginning with $\psi_1(t_5, \tau_0)$, are subject to the transient uncertainty ΔE, as ψ_0 *changes continuously* into ψ_1 in time ΔT.

Equation 12.1 can be written in a form in which only launch components are included

$$\Psi(t \geq t_0) = \psi_0(t) + \psi_1(t, \tau_0)d\tau + \ldots$$

and this results in a *realize* component at the time t_{sc} of stochastic choice that equals

$$\Psi(t_{sc} \geq t_0) = \psi_1(t_{sc}, \tau_0) \qquad (12.4)$$

followed by $\Psi(t \geq t_{sc} > t_0) = \psi_1(t, \tau)$

where again we adopt the q-rule term "realized" when describing these wave functions. This is valid to do so long as the components of the wave function qualify as quantum jumps. It must be remembered that the function $\psi_1(t_{sc}, \tau_0)$ in this equation is really $\psi_0(t_{sc}, \tau_0)$, and it only becomes $\psi_1(t, \tau)$ when the transients die out in time ΔT.

The consequences of Eq. 12.4 when dealing with a detector capture and with a neutron decay are illustrated below.

A particle capture

The launch component of the interaction described by Eq. 9.2 develops in two different ways: One is dependent on time t and the other is dependent on the unitless parameter τ. Imagine that the detector contains a clock that is set to read t_0 at the beginning of the experiment and ticks continuously thereafter. Its behavior throughout the experiment will proceed without regard to the possibility of capture, so its variables will depend on the time t. But the ionic cascade that is initiated when the particle enters the detector's window is different. The time of that event is uncertain before there has been a stochastic hit, so the wave equation will include the "possibility" of a cascade beginning at each moment of time after the interaction begins. These are *faux cascades* because they are not empirically real. They exist only in the ready components of the integral, where each is initiated with the setting $\tau_0 = 0$. For the case of the detector d_1, the term $\psi_1(t_k, \tau_0)$ at time t_k in array of Eq. 12.2 is equal to $\underline{d}_1(t_k, \tau_0)$ and represents a faux capture beginning at that time. A *realized* capture (or cascade) beginning at the time t_{sc} of a stochastic hit is therefore given by the component

$$\Psi(t_{sc} \geq t_0) = d_1(t_{sc}, \tau_0)$$

$$\text{followed by } \Psi(t \geq t_{sc} > t_0) = d_1(t, \tau)$$

A free neutron decay

A neutron decay is also characterized by two times like a detector capture. First there is the metric background time t that describes the progress of the neutron across the laboratory before decay, and continues to describe the progress of the decay products after decay. And second, there is the time τ that resets to zero at each moment of time.

Consequently, the neutron will spew out faux decay particles in all directions as it moves across the laboratory, where each of these is keyed to the temporal parameter $\tau_0 = 0$ in Eqs. 12.1 and 12.2. The term $\psi_1(t_k, \tau_0)$ at time t_k in the array of Eq. 12.2 is then equal to $\underline{e}p\bar{\nu}(t_k, \tau_0)$ and represents a *faux decay* beginning at that time. Decay particles will not become empirically real until a time t_{sc} when a stochastic hit collapses the integral, thereby *realizing* a decay with the initial conditions given by

$$\Psi(t_{sc} \geq t_0) = ep\bar{\nu}(t_{sc}, \tau_0)$$

$$\text{followed by } \Psi(t \geq t_{sc} > t_0) = ep\bar{\nu}(t, \tau)$$

In the q-rule equations appearing throughout this book the transient time ΔT and the associated energy uncertainty ΔE are very often ignored.