II.C.1. Spin and Angular Momentum Conventions

For any analysis or evaluation, the analyst bears ultimate responsibility for including the proper spin-group definitions.

This is not the responsibility of the SAMMY program nor of the SAMMY author. SAMMY will issue warnings for obvious errors, but it is the responsibility of the user to notice and heed those warnings. It is also the responsibility of the user to ensure that the set of spin groups is complete; program SAMQUA, described in Section X.J, can be used for guidance in that effort.

It is worthwhile to discuss what is meant by "complete." Clearly, it is neither necessary nor possible to include all legitimate values of all of the quantum numbers (*l*, *s*, and *J*), because an infinite number of spin groups is available. Generally, one should include low values of *l*, *l* = 0 being always required and *l* = 1, 2, 3, … being included when the experimental data require their inclusion. For each *l*, the user should determine (using SAMQUA or by hand) all possible *s*-values leading to all possible *J*-values. In general, all such channels and spin groups should be included in the analysis. When the hard-sphere phase shift values are sufficiently large that there is a noticeable contribution to the cross section from the hard-sphere phase shift, all such channels must be included. On rare occasions, there may be one resonance (or several) whose high *l*-value dictates the presence of a particular channel in a particular spin group, but for which the hard-sphere phase shift is negligible for all energies of interest in this experiment. In this case, it would be reasonable to omit other channels and spin groups with this same *l*-value, without degrading the quality of the evaluation.

The spin and angular momentum conventions used in SAMMY (and in its predecessor MULTI [GA74]) are described in Table II C1.1. Recall that the word "channel" refers to the physical configuration (e.g., the particular particles involved) as well as to the quantum numbers given here. For example, an incident channel might consist of a neutron (intrinsic spin i = ½) impinging on a target (sample) whose spin is I, so that the channel spin is s, where $\vec{s} = \vec{i} + \vec{I}$. The relative orbital angular momentum of this channel (neutron plus target) is l, and total spin is J, where $\vec{J} = \vec{s} + \vec{l}$. For elastic scattering, the exit channel is the same as the entrance channel. For a reaction such as (n,p), the exit channel contains a proton (spin i' = ½) and another nuclide (spin I'); the channel spin is s', where $\vec{s}' = \vec{i}' + \vec{I}'$. The relative angular momentum proton-nuclide system is $\boldsymbol{l}'$, and the total J must satisfy $\vec{J} = \vec{s}' + \vec{l}'$.

Readers unfamiliar with vector sum rules are referred to Section II.C.1.a for a short summary of the basic principles.

Table II C1.1. Spin and angular momentum conventions used in SAMMY [a]

Symbol	FORTRAN name used in SAMMY	Meaning	Value or range of values
i or i'		Intrinsic spin of incident or outgoing particle	½ for neutron; in general, integer or half-integer
I or I'	SPINI	Spin of target [i.e., sample] or residual nuclei	Integer or half-integer
l or l'	LSPIN (channel 1, group number) *or* LSPIN (whatever channel, group number)	Orbital angular momentum in incident or outgoing channel	Non-negative integer
s or s'	CHSPIN (channel 1, group number) *or* CHSPIN (whatever channel, group number)	Incident or outgoing channel spin, equal to the vector sum of the spins of the two particles in the channel	$\vec{s} = \vec{I} + \vec{i}$ or $\vec{s}' = \vec{I}' + \vec{i}'$
J	SPINJ (group number)	(1) Spin of resonance (2) Spin of excited level in the compound nucleus (3) Total angular momentum quantum number	$\vec{J} = \vec{I} + \vec{s}$ $= \vec{I}' + \vec{s}'$

[a] Note: The channel spin s (s') was denoted by j (j') in early versions of this manual.

The spin statistical factor g_J appearing in the equations for cross section (see Section II.A) is given in terms of the spins *i* and *I* of the two particles in the entrance channel and the total spin *J* of the particular channel; that is

$$g_J = \frac{(2J+1)}{(2i+1)(2I+1)} \qquad \text{(II C1.1)}$$

in the general case, and

$$g_J = \frac{(2J+1)}{2(2I+1)} \qquad \text{(II C1.2)}$$

when the incident particle is a neutron or proton.

A few words of discussion about the use of these quantum numbers in SAMMY are warranted here, to avoid possible confusion:

(1) Values for the spin *i* of the projectile and spin *I* of the target particle are specified in the particle-pair definitions, card set 4 of the INPut file (see Section VI.A). Values for spins i' and I' (for exit particles) are also given in card set 4.

(2) With older input formats, incident spin *i* is assumed to be ½ unless otherwise specified (in card set 3). *I* is given as SPINI in card set 10.1. Values for spins i' and I' are not specified.

(3) Projectile spin *i* and target spin *I* are required for evaluation of the spin statistical factor *g*, and in calculation of the channel spin *s*. Exit particle spins are used to calculate channel spin s' but are otherwise unused.

(4) Channel spins s and s' are used as channel descriptors in the output (LPT or IO file; see Section VII). SAMMY will issue a warning statement (but not abort) if these values are inconsistent (if, for example, $\vec{s} \neq \vec{i} + \vec{I}$).

(5) The orbital angular momentum *l* is used for generating penetrabilities, shift factors, and potential phase shifts.

(6) To the extent that it is possible (depending on which input format is used), SAMMY will warn of inconsistent spin or parity values, and abort when obvious errors occur. Users should read through the SAMMY.LPT file, especially at the beginning of an evaluation, to check for warning messages.

(7) Finally, users are urged to review the discussion in the first two paragraphs of this section, to read and heed the suggestions in Section XI (especially those under the heading “Step 2. Preparation of INPut and PARameter files”), and to make use of the auxiliary code SAMQUA when preparing the spin group information.