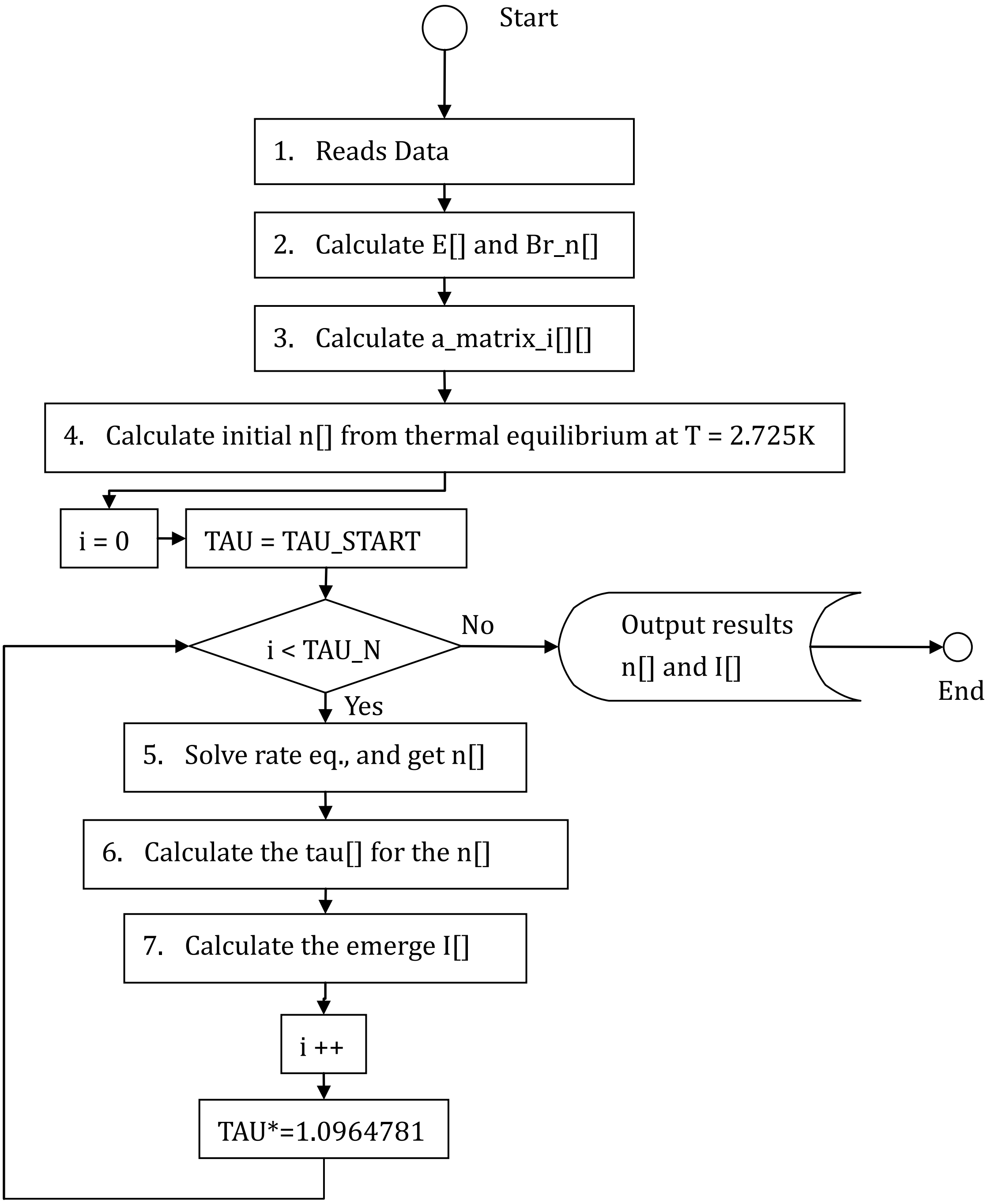
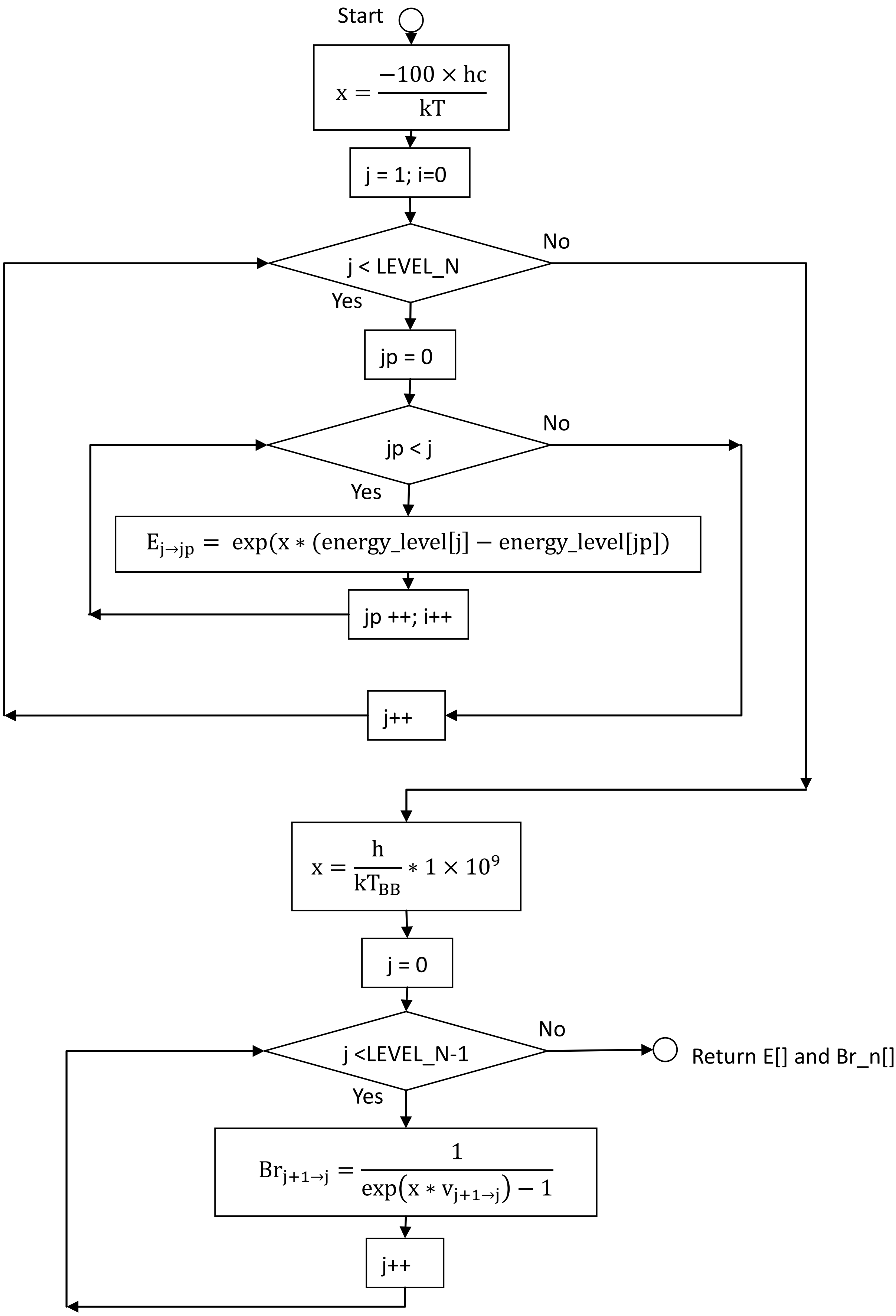
Flow Chart for c3.4 (2010.05.04)

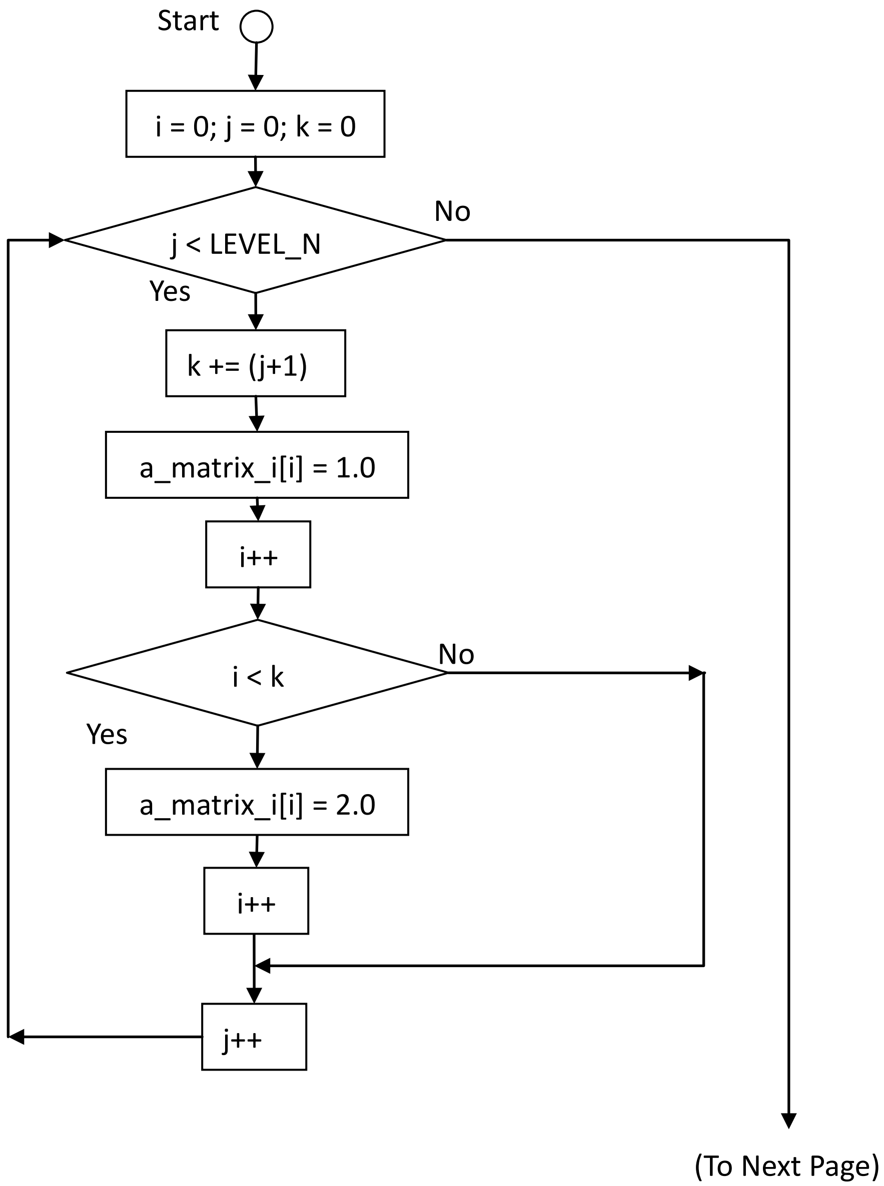
Main Structure

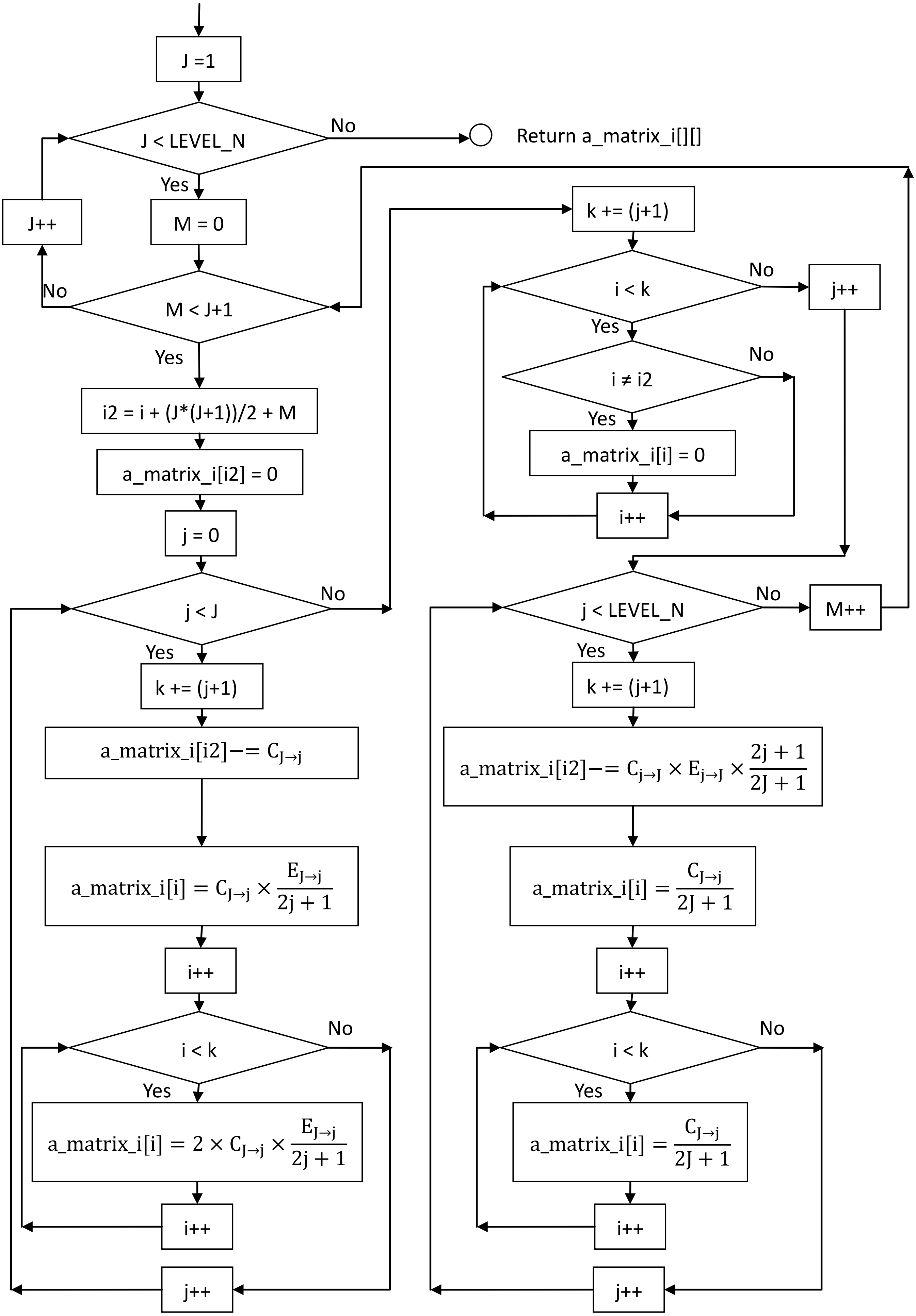


2. Calculate E[] and Br_n[]

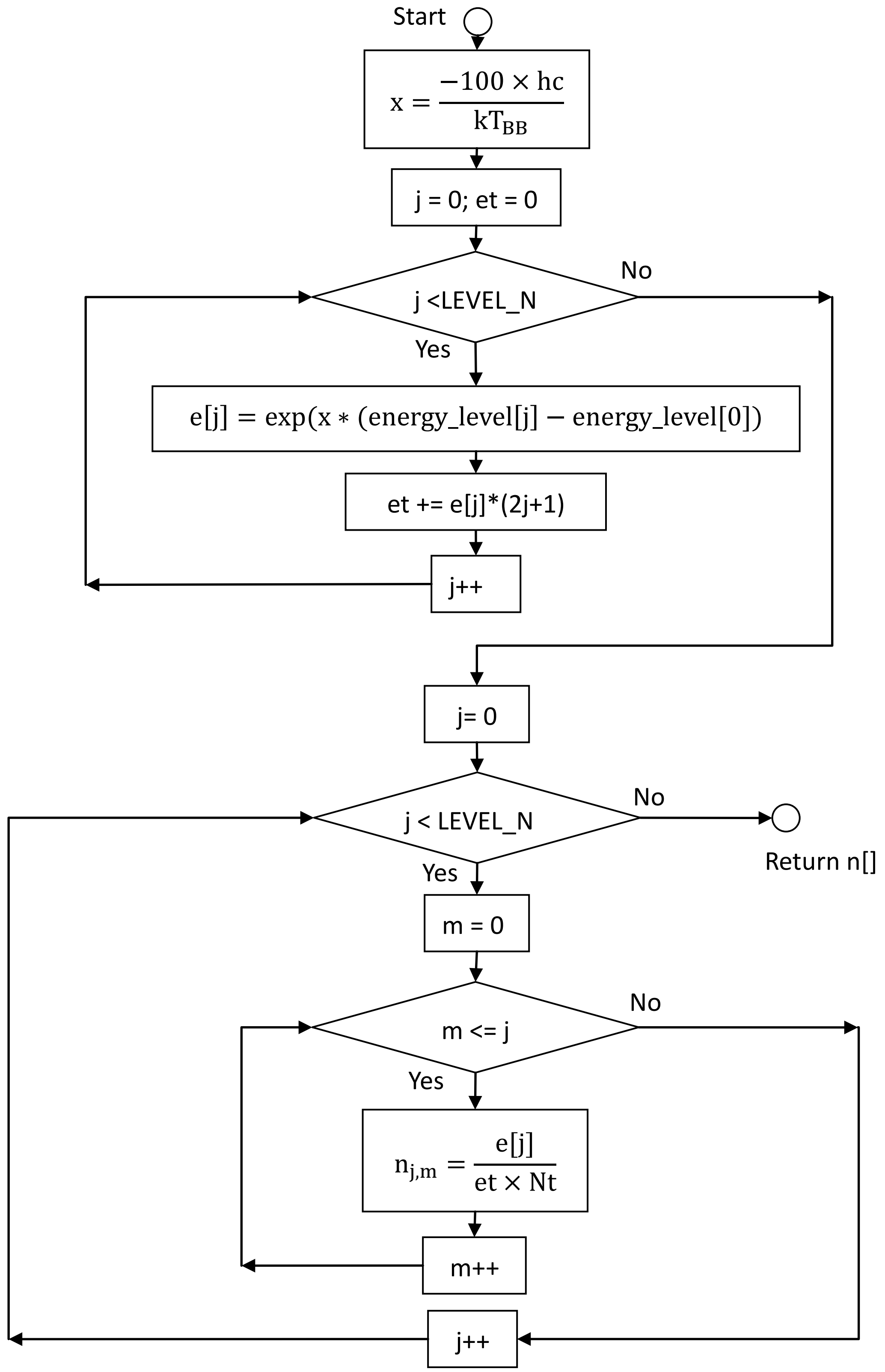


3. Calculate a_matrix_i[][]

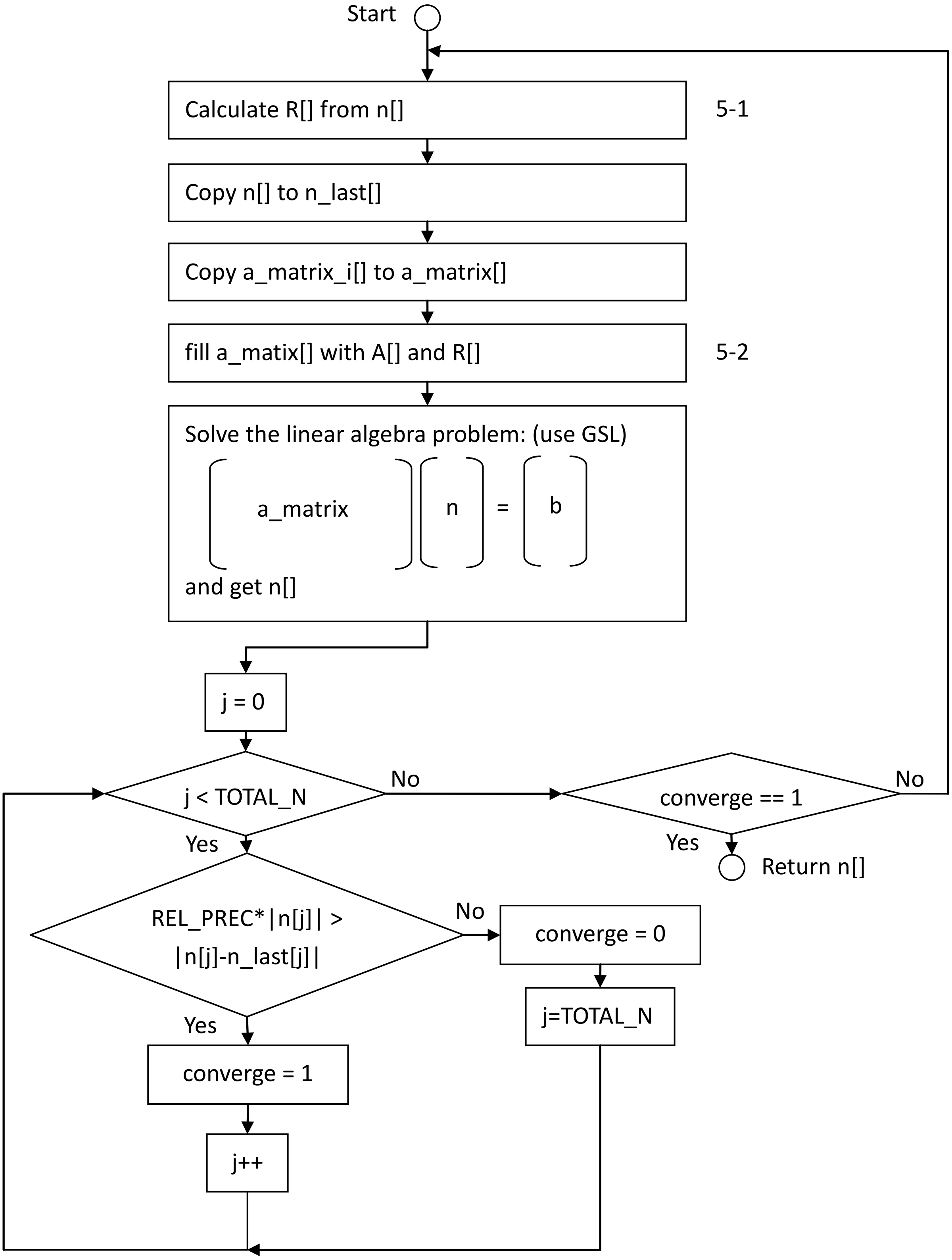



J =1
J < LEVEL_N
No
Return a_matrix_i[][]
Yes
J++
M = 0
No
M < J+1
Yes
i2 = i + (J*(J+1))/2 + M
a_matrix_i[i2] = 0
j = 0
j < J
No
Yes
k += (j+1)
$a\_matrix\_i[i2] -= C_{J \to j}$
$a\_matrix\_i[i] = C_{J \to j} \times \frac{E_{J \to j}}{2j+1}$
i++
i < k
No
Yes
$a\_matrix\_i[i] = 2 \times C_{J \to j} \times \frac{E_{J \to j}}{2j+1}$
i++
j++
k += (j+1)
i < k
No
j++
Yes
i ≠ i2
No
Yes
a_matrix_i[i] = 0
i++
j < LEVEL_N
No
M++
Yes
k += (j+1)
$a\_matrix\_i[i2] -= C_{j \to J} \times E_{j \to J} \times \frac{2j+1}{2J+1}$
$a\_matrix\_i[i] = \frac{C_{J \to j}}{2J+1}$
i++
i < k
No
Yes
$a\_matrix\_i[i] = \frac{C_{J \to j}}{2J+1}$
i++
j++

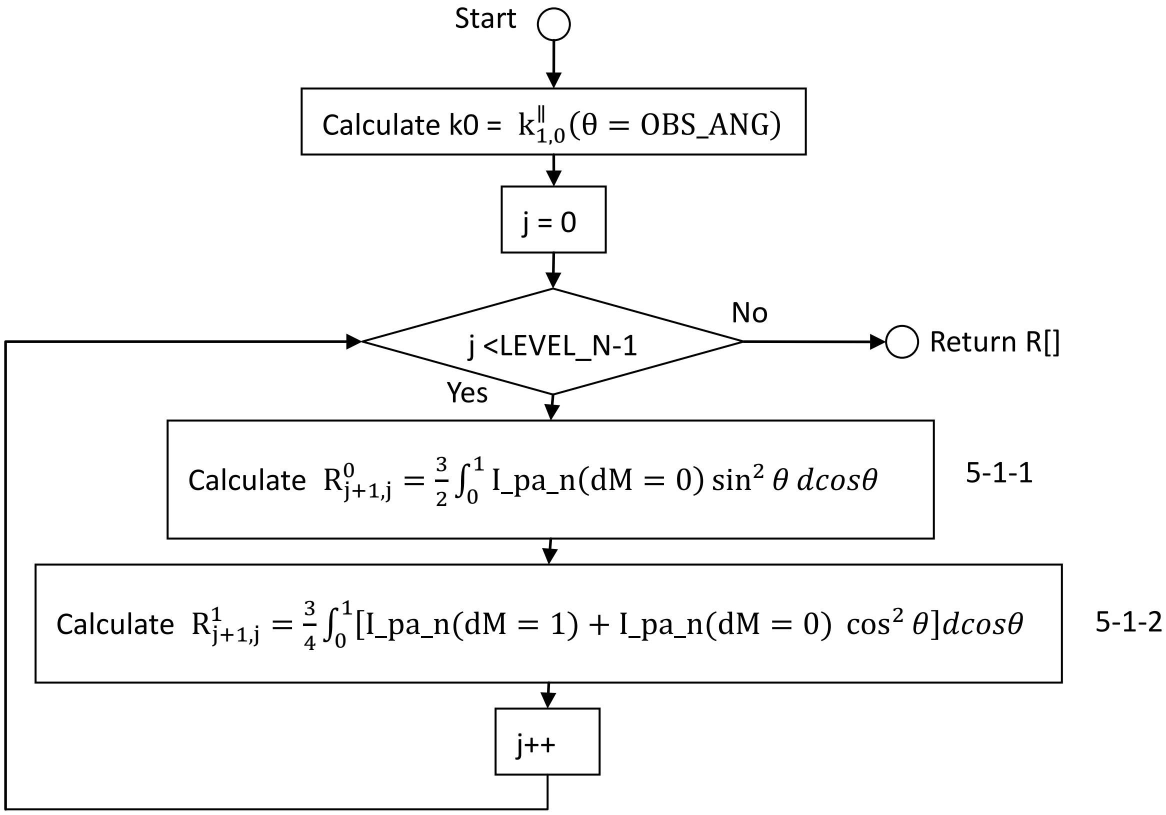
4. Calculate initial n[] from thermal equilibrium at T = 2.725K



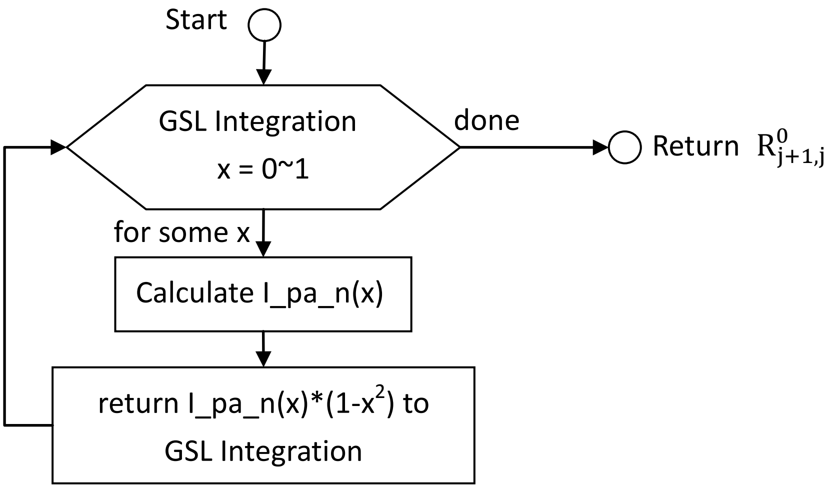
5. Solve the rate eq. and get n[]



5-1 Calculate R[] from n[]



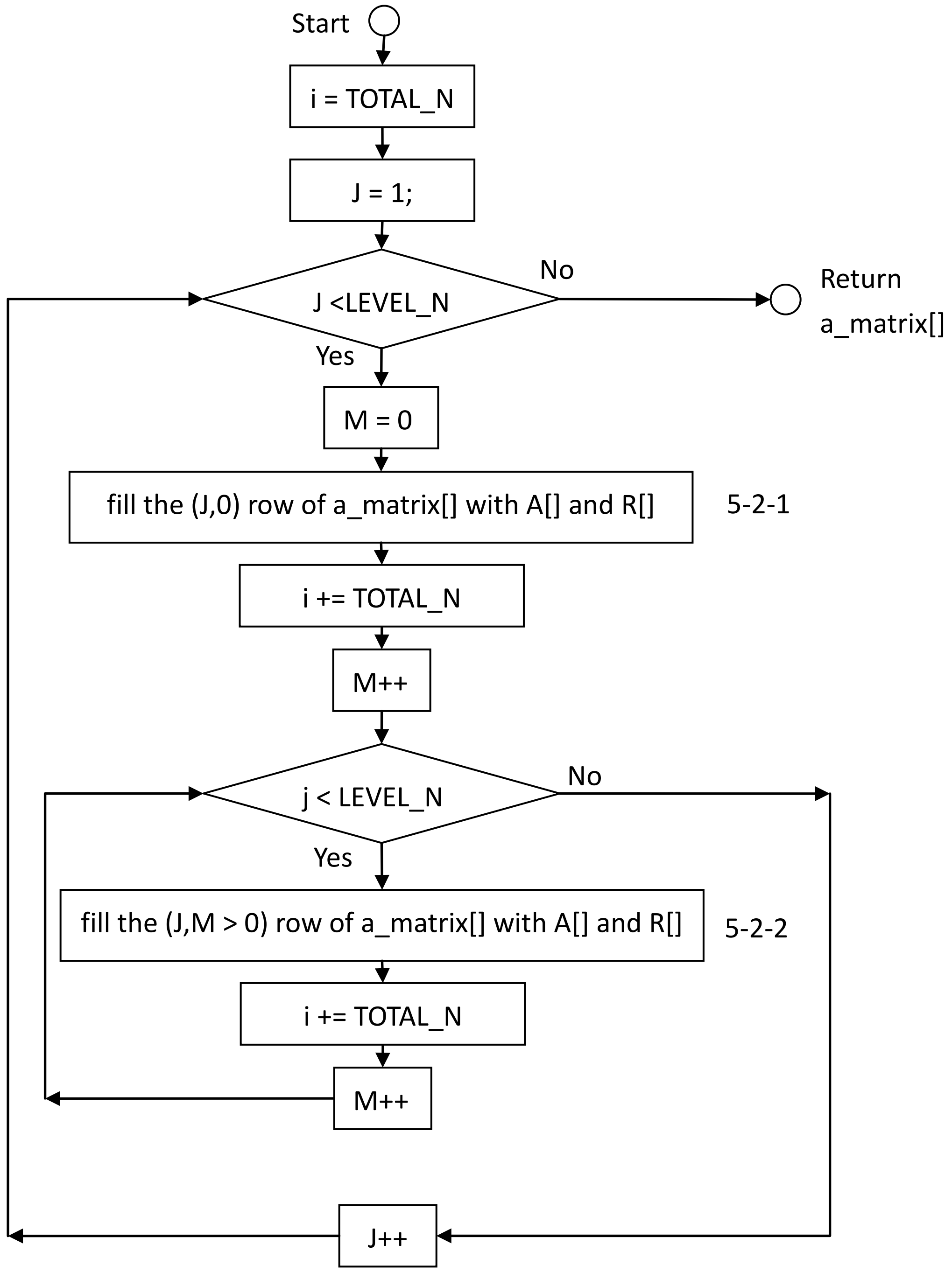
5-1-1 $R^{0}_{j+1,j} = \frac{3}{2}\int_0^1 \mathrm{I\_pa\_n}(\mathrm{dM} = 0)\sin^2\theta\, d\cos\theta$



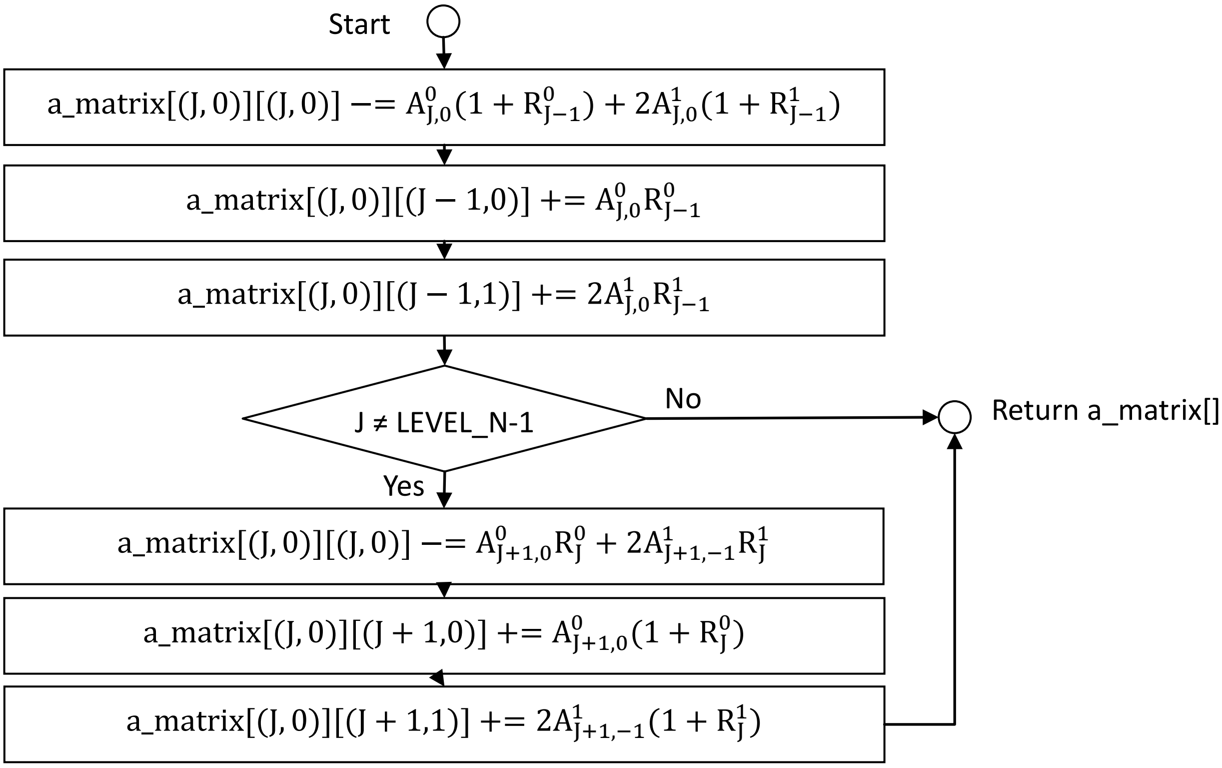
5-1-2 $R^{1}_{j+1,j} = \frac{3}{4}\int_0^1 [\mathrm{I\_pa\_n}(\mathrm{dM} = 1) + \mathrm{I\_pa\_n}(\mathrm{dM} = 0)\ \cos^2\theta] d\cos\theta$

use the similar way as 5-1-1

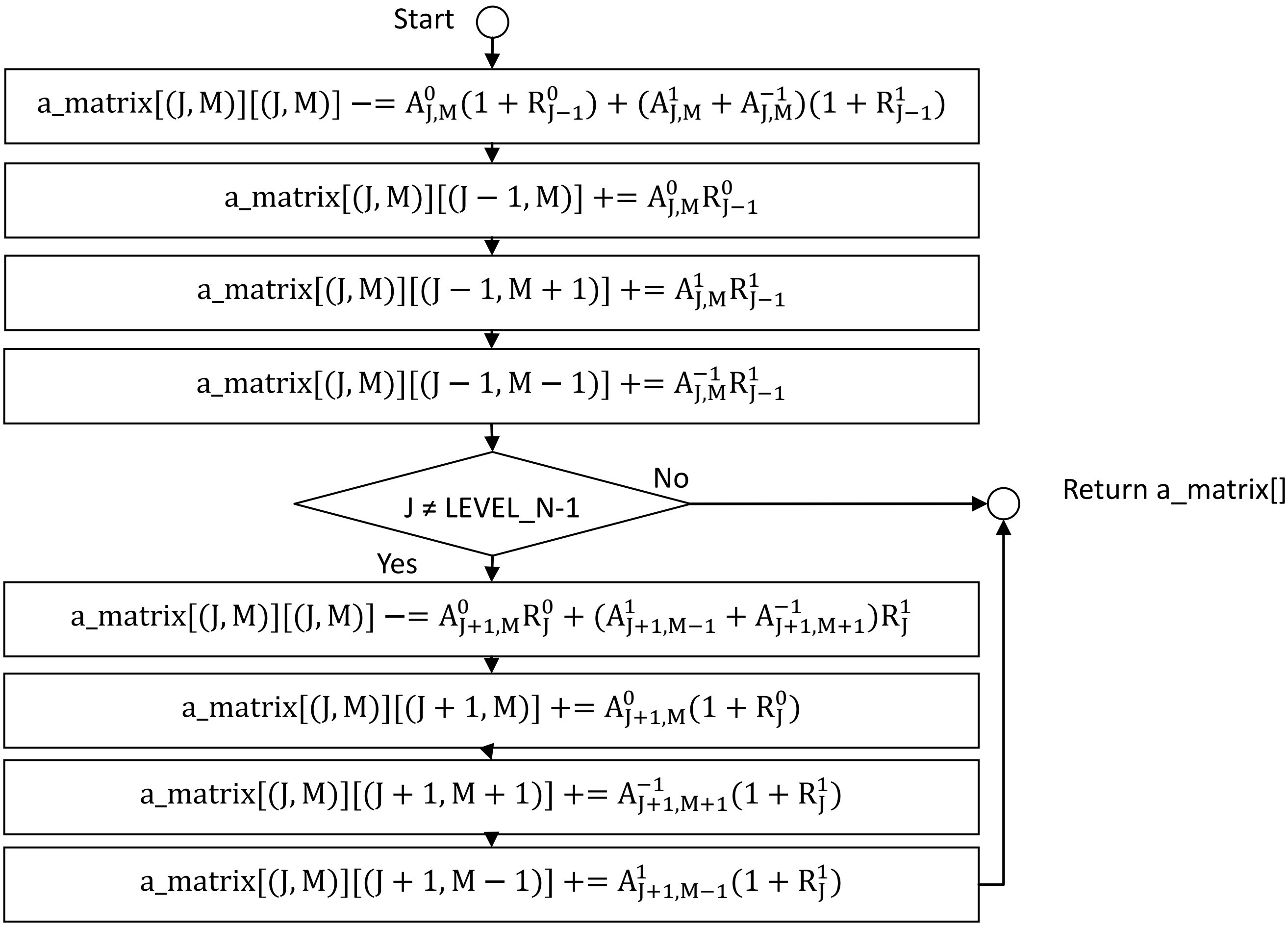
5-2 fill a_matix[] with A[] and R[]



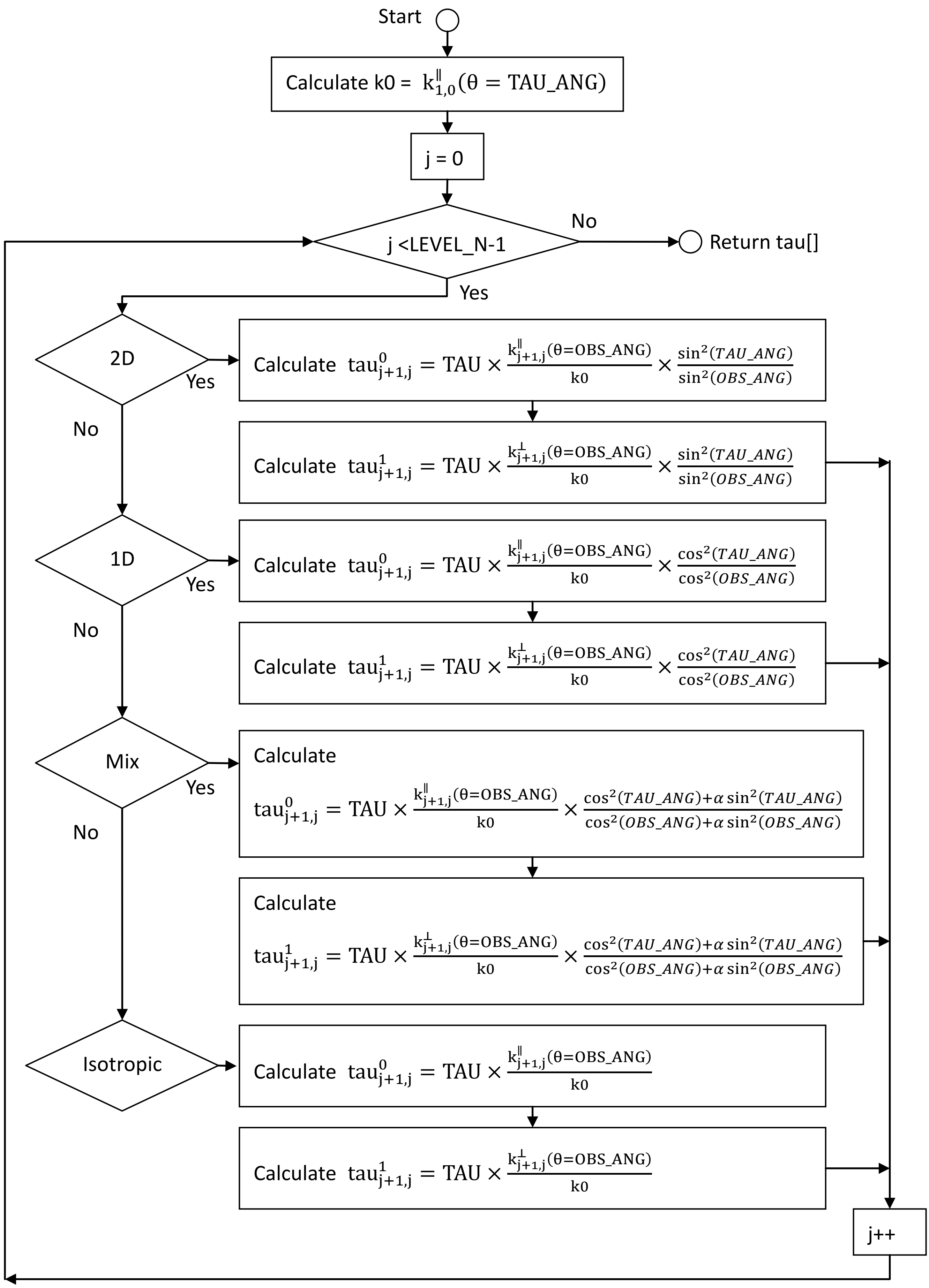
5-2-1 fill the (J,0) row of a_matrix[] with A[] and R[]



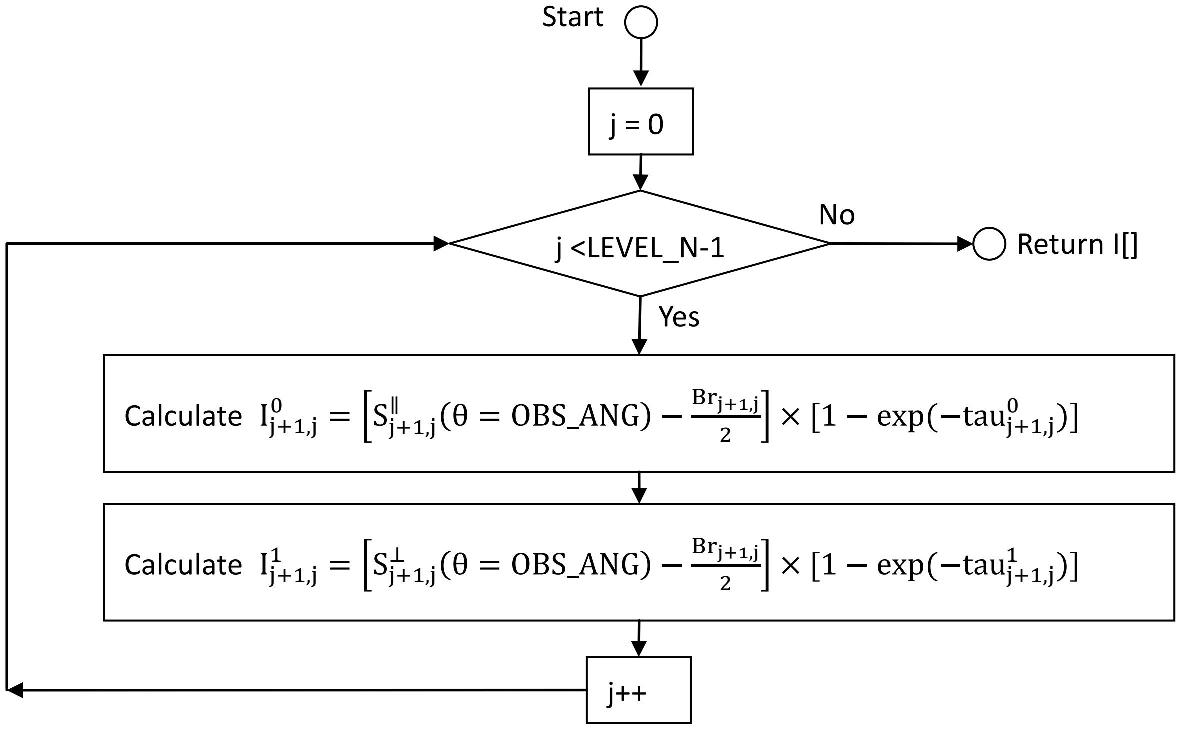
5-2-2 fill the (J,M > 0) row of a_matrix[] with A[] and R[]



6. Calculate the tau[] for each levels



7. Calculate the emerge I[]

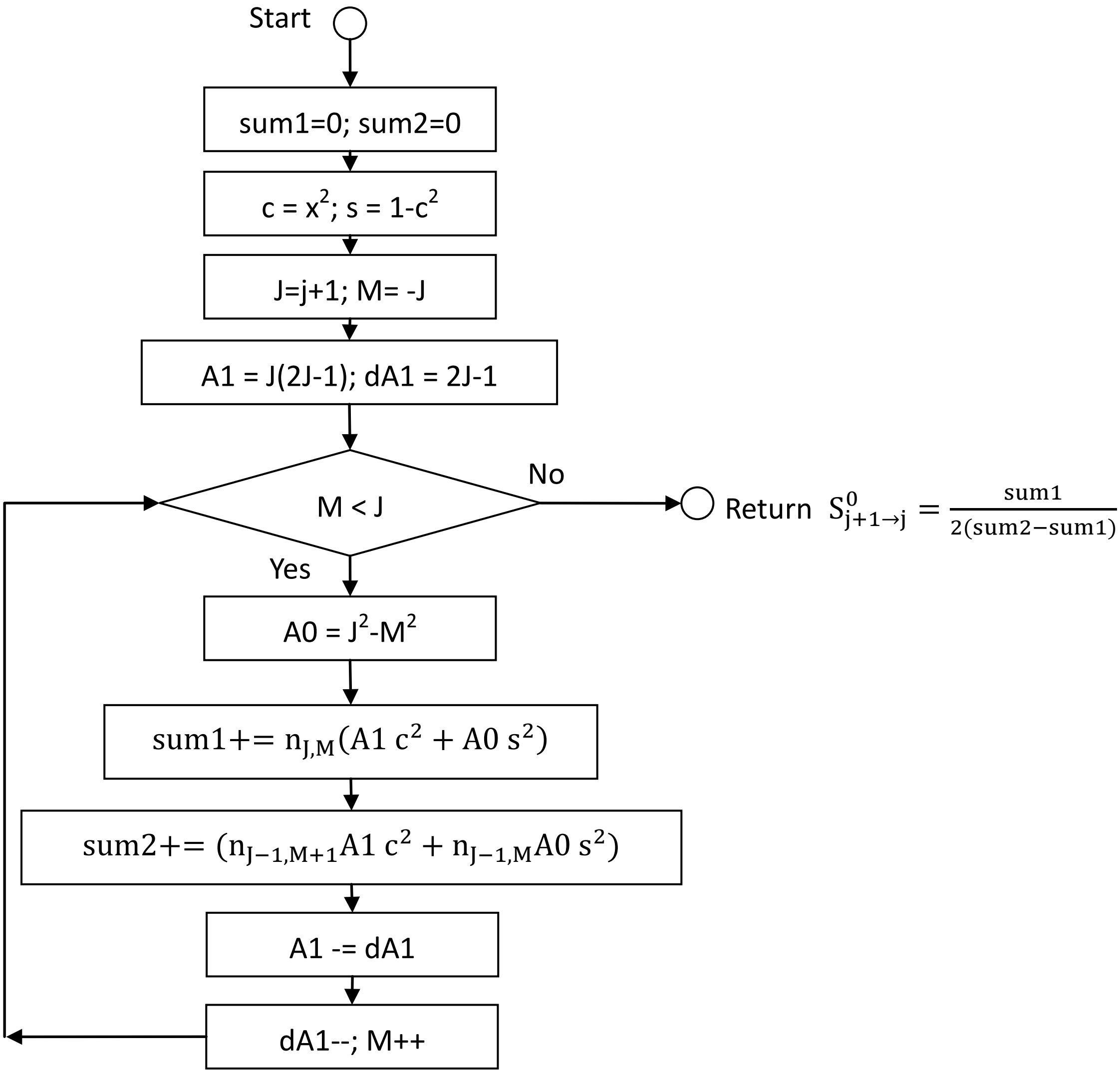


Other function:

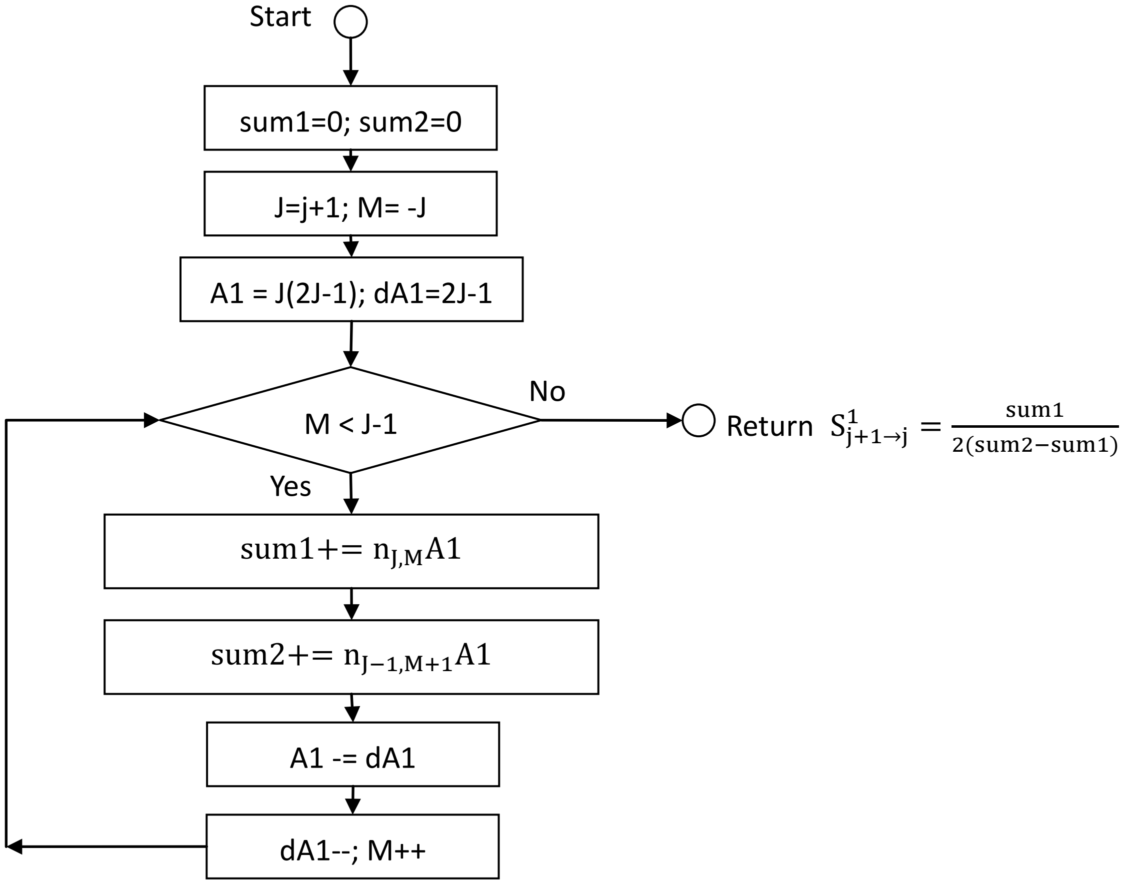
(1) $\text{beta\_f}(\tau = \text{tau}) \equiv \beta(\tau) = \frac{1-e^{-\tau}}{\tau}$

(2) $\text{I\_pa\_n}(\text{angle} = x = \cos\theta, q = \text{dM}, \text{tau\_d}, j) = S^{q}_{j+1\to j}(x) \times \left(1 - \beta(\text{tau}_d)\right) + \frac{\text{Br}_{j+1\to j}}{2} \times \beta(\text{tau}_d)$

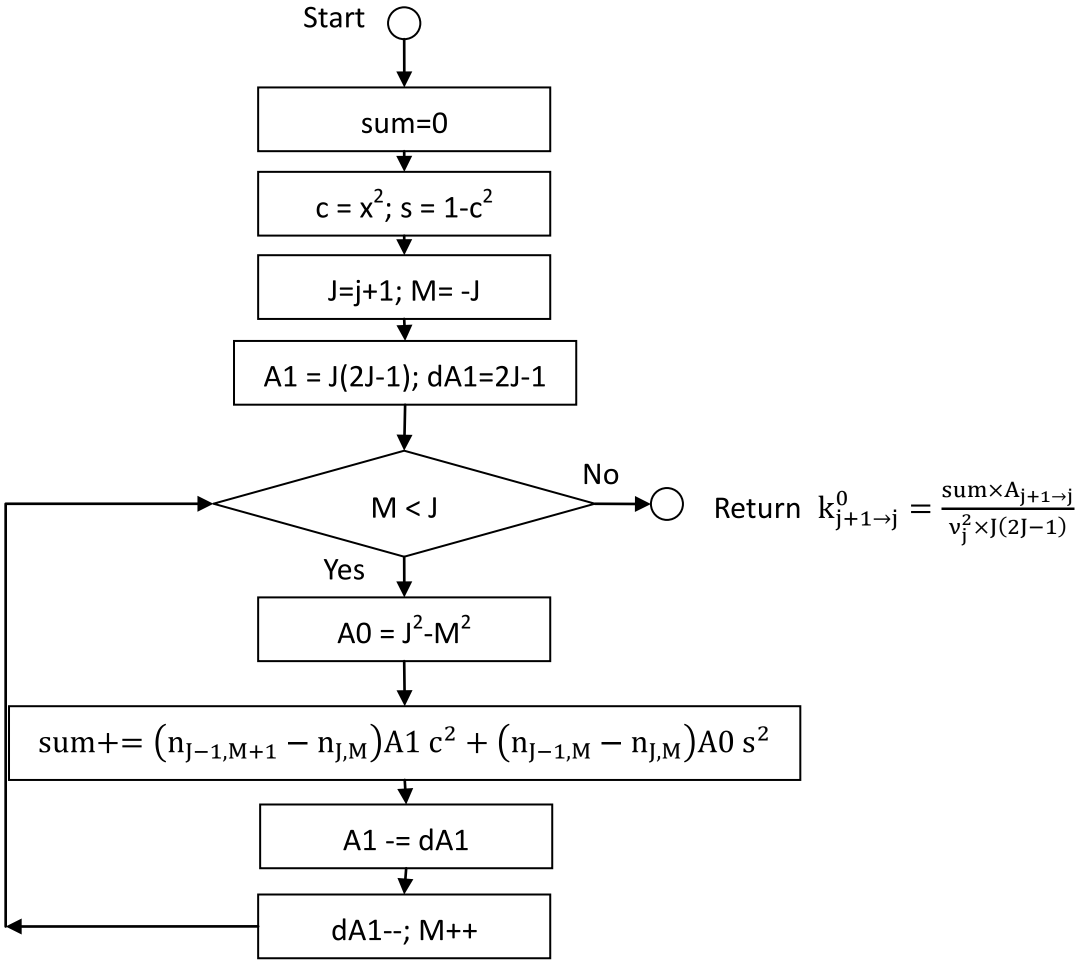
(3) $S^{0}_{j+1\to j}(x = \cos\theta) = S^{\parallel}_{j+1,j}(x = \cos\theta) = \text{source\_f\_n}(\text{angle} = x = \cos\theta, 0, J = j+1)$



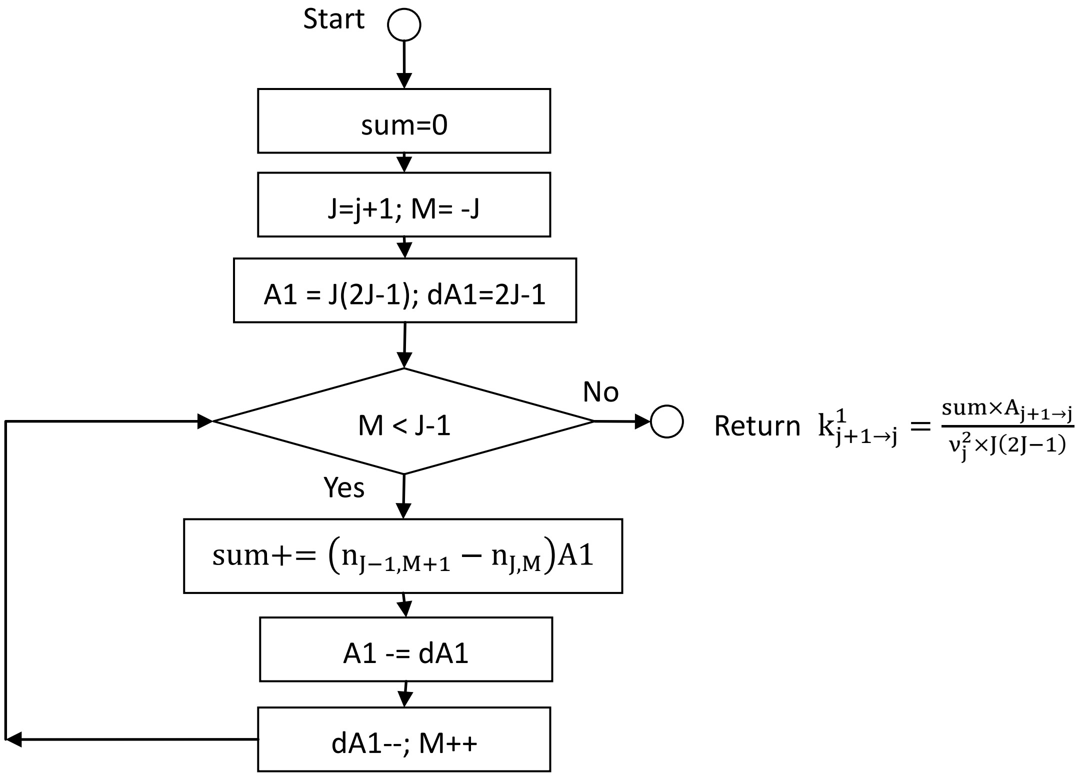
(4) $S^{1}_{j+1\to j} = S^{\perp}_{j+1,j}(\text{no angle dependence}) = \text{source\_f\_n}(\text{angle} = x = \cos\theta, 1, J = j+1)$



(5) $k^{\parallel}_{j+1,j}(\theta = \text{OBS\_ANG}) = k^0_{j+1\to j} = \text{k\_f\_n}(\text{angle} = \cos\theta\,, 0, j)$



(6) $k^{\perp}_{j+1,j} = k^{1}_{j+1\to j}$ (no angle dependence) $= \mathrm{k\_f\_n}(\mathrm{angle} = \cos\theta, 1, j)$



(7) $Br_{j+1\to j} = \mathrm{Br\_n}[\,j\,]$: normalized Cosmic Blackbody Radiation intensity for transition j+1 -> j

(8) $A_{j+1\to j} = A[\,j\,]$: Einstein A coefficients for transition j+1 -> j

Note:

$$A_{J,M\to(J-1),M+dM} = A_{J\to(J-1)} \times \begin{cases} \dfrac{J^2 - M^2}{(2J-1)J} & , dM = 0 \\ \dfrac{(J+M)(J-1+M)}{2(2J-1)J} & , dM = -1 \\ \dfrac{(J-M)(J-1-M)}{2(2J-1)J} & , dM = +1 \end{cases}$$

$A_{J,M\text{->}J-1,M-1}$ is equivalent to the following process: