

which yields

$$\nabla \psi_{mn}^1 = \begin{pmatrix} k(2m+1)^{-1} [mh_{m-1}^2(kr) - (m+1)h_{m+1}^2(kr)] P_m^n(\cos \vartheta) \cos(n\varphi) \\ r^{-1} h_m^2(kr) [(m-n+1)P_{m+1}^n(\cos \vartheta) - (m+1)\cos \vartheta P_m^n(\cos \vartheta)] \cos(n\varphi) \\ - n(r \sin \vartheta)^{-1} h_m^2(kr) P_m^n(\cos \vartheta) \sin(n\varphi) \end{pmatrix} \quad (8.4)$$

and

$$\nabla \psi_{mn}^{-1} = \begin{pmatrix} k(2m+1)^{-1} [mh_{m-1}^2(kr) - (m+1)h_{m+1}^2(kr)] P_m^n(\cos \vartheta) \sin(n\varphi) \\ r^{-1} h_m^2(kr) [(m-n+1)P_{m+1}^n(\cos \vartheta) - (m+1)\cos \vartheta P_m^n(\cos \vartheta)] \sin(n\varphi) \\ - n(r \sin \vartheta)^{-1} h_m^2(kr) P_m^n(\cos \vartheta) \cos(n\varphi) \end{pmatrix} \quad (8.5)$$

As mentioned above, straightforward expansion of the sound field in spherical wave functions can produce severe problems of poor convergence, if the source is nonspherical symmetry. Multipoles can be placed at various positions. With an expansion of the sound pressure measured at some reference points into coefficients of a set of multipoles, the field can be reconstructed to achieve an approximation of the reference sound pressures and, furthermore, interpolated sound pressures at other positions. The same strategy, by the way, can also be applied with regard to the particle velocity. Guidelines for the number and spatial discretization of the reference points are available (Ochmann 1990).

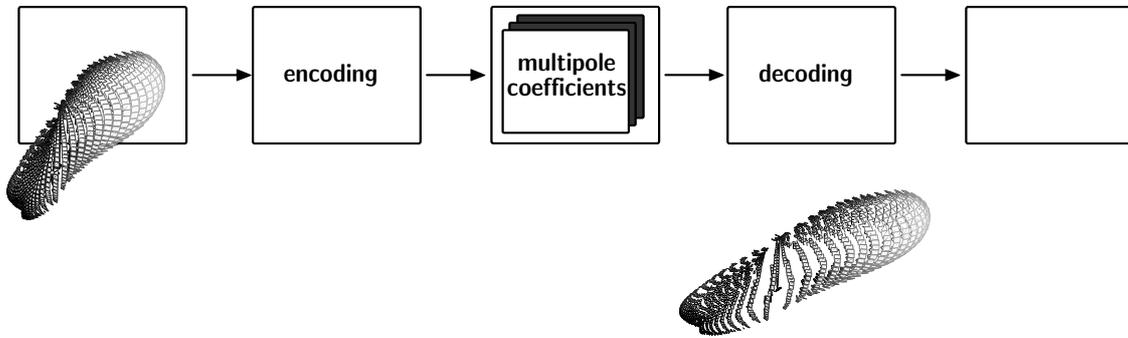


Fig. 8.2. Source directivity encoding

8.1.2 Musical instruments

Signals from musical instruments for auralization can be recorded in anechoic environment (anechoic chamber or, at least a highly absorbing room such as a recording studio) (Giron 1996). Recording must be done in the far field and sufficiently many microphone positions must be used to cover the directional characteristics properly. It must further be ensured that the directional characteristics are constant for all signal components. This fact seems to be no problem for brass instruments since the radiation is dominated from the horn opening (which remains unchanged while playing). In contrast, woodwind instruments have a fluctuating radiation pattern