

# Inverse design: New route to design a practical invisibility cloak

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With the emergence of metamaterials and transformation optics in the past few years, invisibility has become a scientific possibility that has attracted sustainable research interest. Recently, a review paper, entitled "Invisibility cloak from forward design to inverse design", published in *SCIENCE CHINA Information Sciences*, 2013, Vol. 56, reviewed design methodologies and experimental developments of the invisibility cloak from a practical perspective. The recent transition from a forward cloaking design to inverse cloaking design was also addressed. The paper pointed out that the combination of "forward designs" and "inverse designs" rather than using a single cloaking strategy is very likely to make invisibility cloaks far more realistic.

There are three popular design methodologies: the use of transformation optics, conformal mapping, and scattering cancellation. The key point of cloaking techniques is to use materials with specific constitutive parameters and refractive index. A competent candidate is a metamaterial, which can be realized with a collection of artificial "atoms" with subwavelength size and spacing. As artificial "atoms" can be tuned, electromagnetic properties of metamaterials can be engineered almost at will.

Although these three design methods differ sharply in specific means and were developed almost independently without overlap, they share the same goal of reducing the total scattering cross section to a minimum. The three invisibility strategies can be categorized as "forward designs", where the properties of the cloak can be worked out

only after completing the design process. From a perspective of experimental demonstration, the practical development of an [invisibility cloak](#) based on forward design has several bottlenecks.

The paper focused on the review of an alternative target-oriented invisibility strategy, which is referred to as an "inverse design" and profoundly different from the forward design. From a practical point of view and with reverse thinking, the inverse design allows the possibility of integrating the technical advantages of forward strategies; e.g., (i) the central concept of invisibility is to minimize the total scattering cross section, (ii) anisotropic materials ensure invisibility without violating the uniqueness theorem of the inverse problem, and (iii) non-superluminal propagation provides cloaking performance with a relatively broad bandwidth. With these advantages, the backward cloaking strategy may eventually be implemented for a practical large-scale freestanding cloak in free space with relatively broad bandwidth.

Because a target-oriented approach is able to combine all the significant properties, inverse designs integrating desired properties might provide an alternative to current cloaking technology and solve the bottlenecks of individual strategies.

**More information:** Xu S, Wang Y, Zhang B L, Chen H S. Invisibility cloaks from forward design to inverse design. *Sci China Inf Sci*, 2013, 56(12): 120408(11) [info.scichina.com:8084/sciFe/E...abstract512915.shtml](http://info.scichina.com:8084/sciFe/E...abstract512915.shtml)

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