「極限環境状態における現象」
平成９年度採択研究代表者

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「新しい量子自由度・軌道の動的構造の解明」

１．研究実施の概要

本プロジェクトでは、２つの切り口から研究を実施して来た。一つは研究対象となる物質探索及び物質設計の指針を得ることで、我々は新物質合成から純良単結晶育成を行って、中性子並びに放射光X線散乱実験を系統的に進めて来た。もう一つは物理的特性（物性）と研究目標である量子自由度「軌道」の観測の為の実験開発を含めた分光実験技術並びに分光法の理論的な裏付けの確立である。今年度は昨年度迄の研究成果を踏まえて当面の研究課題を次のように設定した。

１）「Spring8」において立ち上げた放射光X線分光装置の性能分析とそれによる実験。

２）マンガン酸化物の軌道秩序並びに軌道の動的構造の観測。

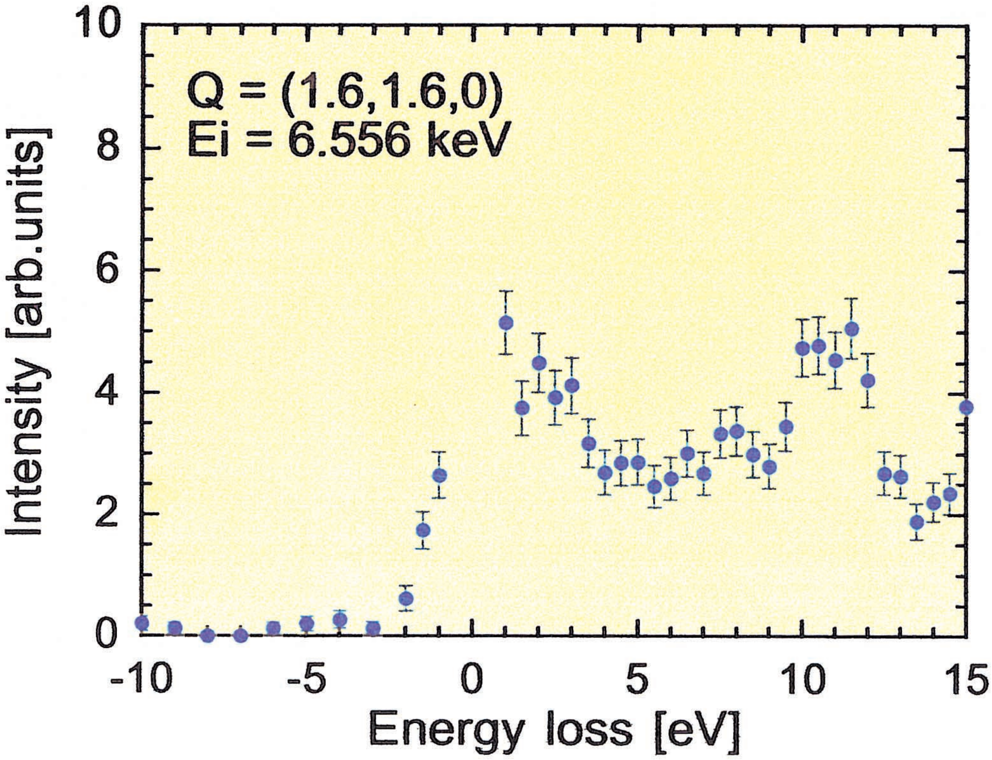
３）高温超伝導銅酸化物のストライプの検証。

４）新しい強相関物質の探索。

２．研究実施の内容

１）SPring8、BL11XUビームラインに新しくX線分光装置の設置を行い、前年度末にその立ち上げにこぎ着けた。設計時の目標値である100meV の分解能で広い逆格子空間で連続スキャンの運転を確認し、その後、目的としている入射放射光のエネルギーを変えながら、広い温度範囲で設計当時に予定した性能試験の確認を行った。

昨年は主として、CMR 物質の母結晶であるLaMnO3 の単結晶のMnの共鳴エネルギー(5.5keV)付近の入射X線に対する非弾性散乱実験を開始した。その結果の一例を下に掲載する。



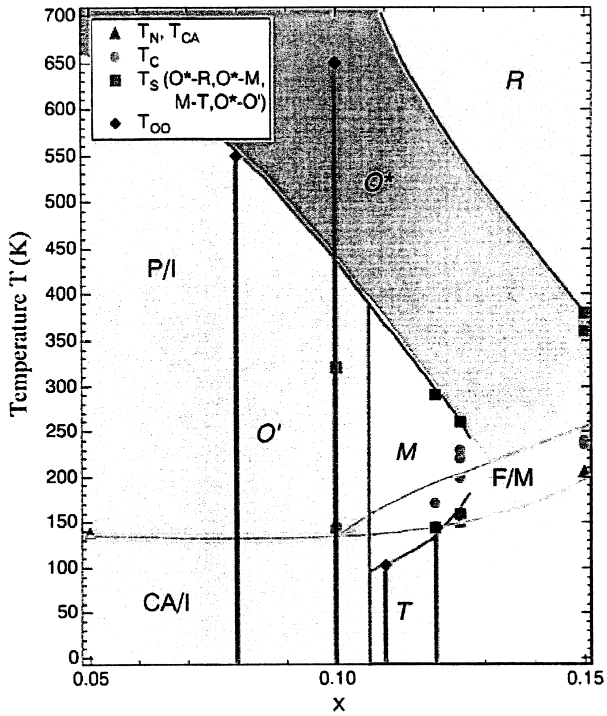
2）マンガン酸化物のCMR（超巨大磁気抵抗効果）の発現機構に深く絡んでいる「軌道」の役割を明らかにする目的で、La0.88Sr0.12MnO 3 の絶縁体・金属転移の発現に注目した。先年度迄に「軌道」秩序と転移との強い相関を明らかにしたが、本年度はこのSr の濃度が特異点であることを、特異点前後での結晶構造、磁気的性質などの解析から、軌道状態が不連続的に変化することとの因果関係を解明した。軌道状態と結晶格子との対応から、従来主張されて来た個別の電子・格子相互作用とは異種の多体電子の相関が導く新しいタイプの相転移に注目している。

3）高温超伝導銅酸化物、特に単一層銅酸化物 La 2 -xSrxMnO4(LSCO)に存在するスピンストライプ構造の安定条件や超伝導発現機構との関連性の実験的な検証が緊急の研究

課題となった。ホール濃度の薄い絶縁相（x < 0.06）とで所謂アンダードープ相（x < 0.12）と呼ばれる領域では伝播方向が異なるものの、性質のよく似た短距離秩序を示すスピンストライプの存在を確認した。それとは別にx = 0.12 付近に比較的長距離のスピンストライプが超伝導と共存して実現することが判明した。

この２種類の性質の異なるスピンストライプの安定性の解明が高温超伝導の問題に繋がる問題と認識して更に研究を進めている。

$La_{1-x}Sr_xMnO_3$



４）金属酸化物よりモビリテイの大きな強相関電子系として硫化物を研究対象に取りあげた。典型物質として 低温でホール係数やゼーベック係数が大きな温度変化を示すNiS2（半導体）は低温で複雑な反強磁性磁気構造をとることが知られている。この物質に動的な縮退状態（スピンフラストレイション）を示す特異なスピン揺らぎを中性子散乱で見つけることが出来た。低温の長距離秩序状態では、この縮退が解かれて格子歪みを伴ってスピンの規則状態を創ることも実験的に明らかにした。この時にはスピン揺らぎに縮退を解くのに必要なエネルギーギャップを伴っていることも判明した。

電子（電荷、スピン、軌道）と格子とが複雑に相互作用する系に共通な自己組織構造の形の一つであろうと考えられる発見に繋がることを期待している。将来、NiS2を化学的な処理によって電子にモビリテイを与え、これが新しい応用へと発展する研究も考えている。

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